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Testing the advantages of six new hybrid chili pepper genotypes in the lowlands

Ganefianti, D. W.[1*], Rahmadani, R.[1], Alnopri[1] , Herawati, R.[1] , Marlin[1] and Armadi, Y.[2]

[1]Department of Crop Production, Faculty of Agriculture, University of Bengkulu.Jl. W.R. Supratman Bengkulu 38121 Indonesia; [2]Faculty of Agriculture, University of Muhammadiyah Bengkulu, Jalan Bali, Bengkulu, 38119, Indonesia.

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Abstract According to the findings, UNIB C H23 outperformed the comparison varieties and the other tested hybrids. With a potential yield of 12.23 tonnes/ha, the UNIB C H23 hybrid is exhibited superiority in terms of growth (plant height, stem diameter, canopy width, and leaf length) and yield (flowering time, harvest age, fruit length, fruit diameter, fruit weight per fruit, fruit weight per plant, and fruit weight per plot). It is shown that the lowest incidence and severity of Pepper Yellow Leaf Curf Virus (PYLCV) disease (15%). With a potential output of 8.18 tonnes/ha, UNIB C H63 it outperformed other cultivators in terms of growth (plant height, canopy width), yield (fruit diameter, number of fruits per plant, number of fruits per plot), and disease severity (13%).

Keywords: Genotype, Selection, Superior

Introduction

Chili Pepper (*Capsicum annuum* L.) is a horticultural commodity used as a spice in a mixture of dishes, raw materials for the food industry, and medicine. Chili pepper has a high vitamin content, including vitamin C (Pratiwi *et al*., 2020). Chili fruit contains capsaicin, the main capsaicinoid compound in chili peppers that can cause a spicy sensation. This sensation can relieve pain, so this compound is widely used as an analgesic or painkiller in the pharmaceutical field (Hasanah and Fatmawati, 2022). Chili has a significant consumer function and target, causing the economic value of chili to be high. The average price of red chili in traditional markets in 2023 fluctuated, with a price range between IDR 33,000 and IDR 64,000 per kilogram (Badan Pangan Nasional, 2024).

Chili pepper production in Indonesia in 2022 was 1.47 million tons and increased in 2023 to 1.55 million tons (Badan Pusat Statistik, 2024). The projected demand for chili pepper per capita from 2021 to 2024 will continue to increase, with an average growth of 3.47% annually. 2021, chili

[*] **Corresponding Author:** Ganefianti, D. W.; **Email:** dw_ganefianti@unib.ac.id

consumption is expected to increase by 3.55% or reach 1.21 tons. Meanwhile 2024, there is expected to be an increase of 3.25%, so chili consumption will increase from 1.21 million tons in 2021 to 1.38 million tons in 2024. This increase in consumption is due to population growth, which has reached 1.04% per year. The data shows that there is still a need for efforts to increase production in the hope of increasing chili production in the coming years. Various efforts are necessary to increase chili production, one of which is the use of hybrid chili varieties. Soetiarso and Setiawati (2010) stated that in chili commodities, using hybrid varieties can increase productivity and approach its optimal productivity potential, which is 20 tons/ha.

Hybrid varieties are the F1 generation of a cross of a pair or more elders (pure strains) with superior properties (Roy, 2000). Hybrid chili varieties are considered to have higher productivity than non-hybrid chili varieties. Hybrid varieties must be tested before they are developed to ensure they have good potential and meet market needs. The excellence test is conducted to evaluate and ensure that the varieties to be released meet the standards set for superior seeds (Direktorat Jenderal Bina Produksi Hortikultura, 2004). The results of the excellence test will get prospective varieties with the characteristics and advantages of other varieties. The desired advantages include high productivity, disease resistance, and adaptability to various environments.

Plant breeders from Bengkulu University have produced hybrid chili peppers, namely UNIB C H13, UNIB C H23, UNIB C H43, UNIB C H53, UNIB C H63, UNIB C H65, UNIB C H73. These hybrids must still be tested for performance in various environments before release. Research on chili varieties in various locations has also been conducted (Wiratama *et al*., 2013); (Syukur *et al.,*2010). Varieties with high superiority are one of the main objectives in plant breeding that produces good yields. Marliyanti *et al*. (2013) stated that plant yield is a plant's ability to produce or produce results according to its potential. Astutik *et al*. (2017) stated that the MG1012 strain was superior in growth characters, yield components, and yield compared to the comparison varieties Jinggo and Lado. Ganefianti *et al*. (2017) stated that the new hybrid chili (H23) has higher growth and yield performance compared to the varieties IPBCH3 and Tilala.

The lowlands have different environmental conditions than the highlands; this difference can undoubtedly affect the growth and yield of chili. Research by Aryani *et al*. (2022) stated that the growth and yield of cayenne pepper in the highlands were lower than in the lowlands. Testing hybrids in an environment that matches the leading cultivation site ensures that hybrid varieties perform well in commercial conditions. A new hybrid chili that Bengkulu University has produced has a productivity of up to 10 tons ha-1 and is also resistant to Begomovirus, which is the cause of yellow curly leaf disease in chili (Ganefianti *et al*., 2017). The new hybrid does not know whether it can adapt well to all environments. For this reason, it was necessary to test in various environments to know whether the new hybrid

chilies that Bengkulu University plant breeders have produced can adapt. This research was conducted in the lowlands to know, if the new hybrid chilies Bengkulu University plant breeders production can adapt well.

Materials and methods

This research was conducted from October 2023 to March 2024 in the experimental field of the Department of Crop Production, Faculty of Agriculture, Bengkulu University, at an altitude of ± 10 m above sea level. The tools used in this research were practical farming tools, stationery, and digital scales. Materials used in this study were seeds of 6 new hybrid chili genotypes, two comparison varieties (LADO and TARO), mulch, dolomite lime, vermicompost, furadan, pesticides, and pearl NPK.

This study was conducted using a randomized complete block design (RCBD) with one factor consisting of 6 new hybrid chili genotypes (UNIB C H13, UNIB C H23, UNIB C H43, UNIB C H433, UNIB C H63, UNIB C H73) and two comparison varieties TARO and LADO. Each treatment was repeated three times, resulting in 24 experimental units. Each experimental unit contained 15 plants, with six plants as sample plants. The research stages include seeding, seeds were soaked in warm water for 12 hours and then germinated on wet merang paper for ± 5 days, then sown on seedling trays. The seedbed used a mixture of topsoil, manure, and husk charcoal (1:1:1). The seedling holes were treated with Carbofuran insecticide. Four-week-old seeds were ready to be transplanted to the field. Land cultivation was done using a hand tractor. Next, the beds were divided into three blocks with a distance of 0.5 m between blocks. Each block had eight beds measuring 7.5 m x 0.7 m with a height of 0.3 m and a distance of 0.5 m between plots. Thus, the total number of beds was 24 beds. Dolomite lime and vermicompost were applied. Planting and transplanting were done when the seedlings were four weeks old (six-leafed). Chili is planted in one row in a bed, 15 plants in a bed with 6 sample plants. Maintenance includes watering, fertilizing, replanting, weeding, controlling pests and plant diseases, and cutting weeds around the plants. Pest and disease control is carried out when plants are affected by pest attacks. Harvesting is done when the chili fruit has reached a red color change. Harvesting was done seven times with a vulnerable harvest time of once a week. The observation variables are plant height (cm), stem diameter, canopy width (cm), dichotomous height (cm), leaf length (cm), leaf width (cm), flowering time (hst), and harvest age (hst). Fruit length (cm), fruit diameter (mm), weight per fruit (g), number of fruits per plant, number of fruits per plot, fruit weight per plant (g), fruit weight per plot (g), PYLCV (*Pepper yellow leaf curl virus*) disease incidence and severity,

The incidence calculation was done using the following formula:

$$I=n/N \times 100\%$$

Description: I = Disease Incidence (%); n = Number of symptomatic plants; N = Total number of plants observed

PYLCV (*Pepper yellow leaf curl virus*) disease severity Calculation of incidence was done by using the following formula: $KP=\sum(ni \times zi)]/(N \times Z) \times 100\%$

Description: KP = Disease Severity (%); ni = Number of symptomatic plants with a particular score value; zi = Symptom score value; N = Total number of plants observed; Z = Highest symptom score value.

Scoring of PYLCV disease symptoms (Ganefianti *et al.,* 2008) Score Severity criteria

0 No symptoms
1 Yellow symptoms
2 Yellow and curly leaves
3 Curling and curling downward or upward
4 Symptoms of yellow leaves and curling downward and upward
5 Symptoms of yellow curly leaves curling downward and upward and stunted plants

The obtained data were analyzed using Analysis of Variance. The Duncans Multiple Range Test is conducted at the 5% level if there is a significant effect. A correlation test was conducted to determine the closeness of the relationship between observational variables.

Results

The study was conducted during a season where rainfall intensity ranged from relatively low at planting to high at harvest. 100.1 mm of rain fell during the planting phase, 33.2 mm during the blossoming phase, 234.3 mm during the fruit development period, and 419.5 mm during the harvest phase (Table 1).

Table 1. Rainfall data at planting sites during plant growth

Phase	Rainfall (mm/month)	Rainfall intensity category
Planting	100,1	medium
Flowering	33,2	low
Fruit formation	234,3	medium
Harvest	288,4 - 419,5	medium-high

Outcomes of the variance analysis

Six new hybrid chili peppers and two comparative kinds were subjected to an analysis of variance test, and the results indicated that 15 observation factors had significant variations across the types. In contrast, the two variables had no significant influence. Plant height, stem diameter, dichotomous height, canopy width, leaf length, leaf width, flowering time, harvest age, fruit length, fruit diameter, weight per fruit, number of fruits per plot, fruit weight per plant, fruit weight per plot, and PYLCV disease severity were the analysis results that significantly affected each other. The number of fruits per plant and the incidence of PYLCV disease were the only two analyses of variance results that did not significantly affect the other variables (Table 2).

Table 2. Analysis of eight chili genotypes on growth, yield, and PYLCV disease incidence and severity characters

Number	Variable	Means Square	Treatment value F	Coefficient of variation (%)
1	Plant height	81.46	11.89*	2.74
2	Stem diameter	0.97	11.95*	2.76
3	Dichotomous Height	4.07	7.03*	2.51
4	Canopy width	3.91	4.06*	2.08
5	Leaf length	0.50	24.85*	1.91
6	Leaf width	0.44	43.29*	3.15
7	Flowering time	4.46	30.23*	1.12
8	Harvest age	19.01	5.71*	2.39
9	Fruit length	9.84	6.99*	11.18
10	Fruit diameter	0.86	3.87*	6.43
11	Weight per fruit	1.53	12.66*	12.46
12	Number of fruit per plant	4899.60	2.31ns	23.83
13	Number of Fruit per plot	814899.12	5.90*	19.15
14	Fruit Weight per Plant	57457.98	5.74*	20.65
15	Fruit Weight per Plot	10507152.00	8.64*	21.74
16	PYLCV Disease Incidence	0.098	2.33ns	11.19^{T}
17	PYLCV Disease severity	0.054	3.20*	8.52^{T}

Notes: * = significant effect, ns = no significant effect

Plant growth character

The plant height of the tested hybrid chili peppers ranged from 87.8 cm to 100.5 cm; for the comparison varieties, it was 87.6 cm to 97.6 cm. UNIB C H23 had the highest plant height of 100.56 cm, equivalent to other tested hybrids: UNIB C H43, UNIB C H433, UNIB C H63, UNIB C H73, and LADO varieties. However, it significantly differed from UNIB C H13, UNIB C H73, and the comparison variety TARO (Table 3).

Table 3. Character appearance of plant height, stem diameter, dichotomous height, canopy width, leaf length, and leaf width of eight chili genotypes

Perlakuan	PH	SD	DH	CW	LL:	LW
C H13	92.7 b	9.7d	30.7ab	50.1ab	7.2B	3.4b
C H23	100.5 a	11.5a	29.1cd	50.6a	7.9A	3.3b
C H43	99.8 a	10.8b	29.8bcd	50.7a	8.2A	4.0a
C H433	96.1 ab	9.9cd	30.3bc	48.2bc	7.4B	2.8d
C H63	99.1 a	10.1cd	30.1bc	49.0abc	7.3B	2.8d
C H73	87.8 c	10.0cd	31.2ab	48.4bc	7.3B	3.1c
TARO	87.6 c	10.2cd	28.4d	47.8c	6.9C	3.1c
LADO	97.6 a	10.2cd	32.1a	48.4bc	7.2B	3.0c

Note. PH= plant height, SD= stem diameter, DH= dichotomous height, CW= canopy width, LL= leaf length, LW=leaf width.
Numbers followed by the same letter in the same column show no significant difference in Duncan's multiple range test (DMRT) 5%.

The evaluated hybrid chili peppers had stem diameters ranging from 9.7 mm to 11.5 mm, while the comparative variety's stem diameter was 10.2 mm. Compared to the other hybrids evaluated (UNIB C H13, UNIB C H43, UNIB C H433, UNIB C H63, UNIB C H73, and the comparative varieties TARO and LADO), UNIB C H23 had a much greater diameter (11.5 mm) (Table 3). Comparable to the other hybrids UNIB C H13, UNIB C H43, UNIB C H433, UNIB C H63, and the comparator variety LADO, UNIB C H73 had a median height of 31.2 cm (Table 3). Compared to the other three hybrids, UNIB C H13, UNIB C H23, and UNIB C H63, UNIB C H43 has the broadest canopy (50.7 cm). Like UNIB C H23, UNIB C H43 has the most extended leaves, measuring 8.2 cm. Comparing this leaf length to UNIB C H13, UNIB C H43, UNIB C H433, UNIB C H63, and UNIB C H73, and the comparison varieties TARO and LADO, however, revealed a substantial difference (Table 3). When compared to the comparative varieties TARO and LADO as well as the other hybrids UNIB C H13, UNIB C H23, UNIB C H433, UNIB C H63, and UNIB C H73, UNIB C H43 had the broadest leaf (4.0 cm), which was substantially different (Table 3).

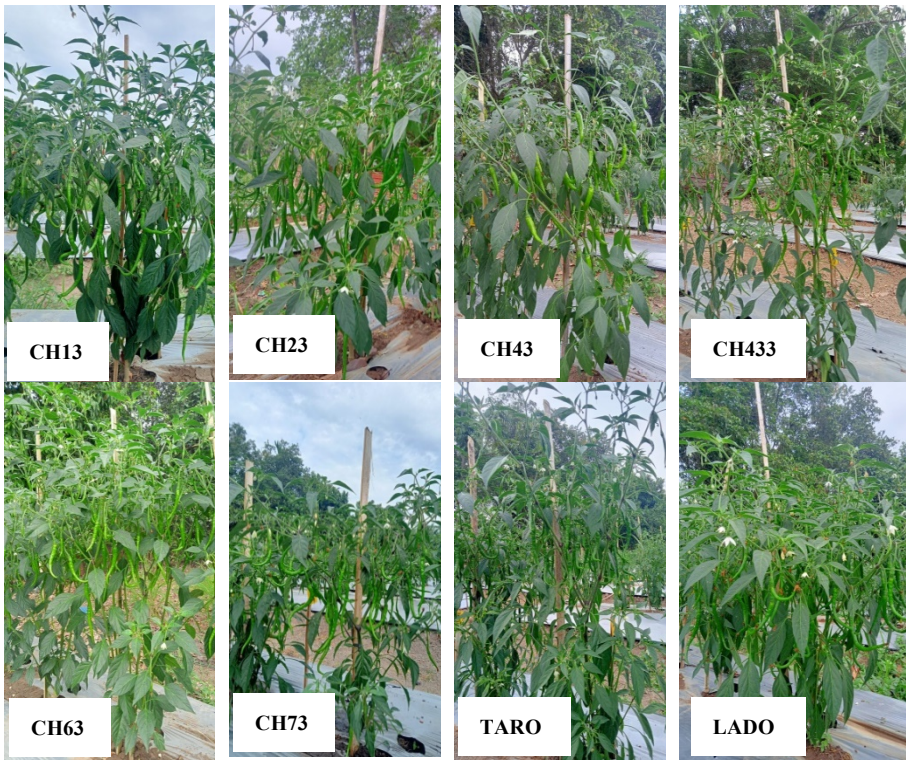

Figure 3. Appearance of six chili pepper genotypes (UNIB C H13, UNIB C H23, UNIB C H43, UNIB C H433, UNIB C H63 dan UNIB C H73) and two comparison varieties (TARO dan LADO)

Plant yield characters

The flowering time of the tested hybrids ranged from 32 to 35 HST, and the comparison variety was 34 HST. UNIB C H23 (32 HST) had the same flowering time as UNIB C H13. However, this flowering age significantly differed from UNIB C H43, UNIB C H433, UNIB C H63, UNIB C H73, and the comparison varieties TARO and LADO (Table 4). Thus, UNIB C H23 had a faster flowering age when compared to the comparator varieties TARO and LADO. The harvesting age of the tested hybrids ranged from 72 to 78 HST, and the comparison varieties ranged from 77 to 78 HST. UNIB C H23 (72 HST) was similar to UNIB C H13 and UNIB C H43. However, this harvest age significantly differed from UNIB C H433, UNIB C H63, UNIB C H73, and the comparison varieties TARO and LADO (Table 4).

Table 4. Flowering time, harvest age, fruit length, fruit diameter, weight per fruit, number of fruits per plant, number of fruits per plot, fruit weight per plant, and fruit weight per plot of eight chili genotypes

Treatment	FT	HA	FL	FD	WPF	NFP	NFO	FWP	FWO
C H13	32b	73b	11.3abc	7.1bcd	3.0 Bc	179	1792bc	588.3Ab	5563.7 b
C H23	32b	72b	13.1abc	8.2a	4.3 A	207	2092bc	733.9A	8929.4 a
C H43	35a	73b	7.3d	7.8ab	2.3 D	156	1456c	298.6D	2800.0 d
C H433	34a	78a	10.6bc	6.9cd	2.4 Cd	161	1415c	349.1Cd	3301.6 cd
C H63	35a	78a	9.0cd	7.5abc	2.3 D	254	2845a	491.4Bc	5534.3 b
C H73	34a	77a	12.2ab	7.4abcd	3.2 Bc	138	1406c	401.1Bcd	4145.8 bc
TARO	34a	77a	10.7bc	7.0bcd	2.2 D	232	2407ab	492.6Bc	5392.6 b
LADO	34a	78a	10.2bc	6.5d	2.4 Cd	213	2095bc	518.3Bc	4989.2 bc

Note: FT = Flowering time, HA = harvest age, FL= fruit length, FD=fruit diameter, WPT= weight per fruit, NFP= number of fruits per plant, NFO= number of fruits per plot, FWP= fruit weight per plant, FWO= fruit weight per plot.
In Duncan's multiple range test (DMRT) 5%, numbers in the same column followed by the same letter indicate no significant difference.

The studied hybrid chilies ranged from 7.3 to 13.1 cm, while the comparative cultivars ranged between 10.2 and 10.7 cm. With its longest fruit measuring 13.1 cm, UNIB C H23 did not differ much from UNIB C H13 and UNIB C H73. Comparing this fruit length to UNIB C H43, UNIB C H433, UNIB C H63, and the reference types TARO and LADO, however, revealed a substantial difference (Table 4). Thus, the most extended fruit belongs to UNIB C H23. The comparison varieties' fruit diameters varied from 6.5 mm to 7.0 mm, whereas the tested chili hybrids' fruit diameters ranged from 6.9 mm to 8.2 mm. The greatest fruit diameter, 8.2 mm, was recorded by UNIB C H23.

The weight parameters of each evaluated hybrid chile fruit varied between 2.3 and 4.3 g and between 2.2 and 2.4 g for the comparator variety. When compared to UNIB C H13, UNIB C H43, UNIB C H433, UNIB C H63, UNIB C H73, and the comparator varieties, UNIB C H23 has the most significant weight per fruit, weighing 4.3 g. (Table 4). This indicates that UNIB C H23 outperforms TARO and LADO, the comparative kinds, regarding weight per fruit. According to the description, the fruit weight of UNIB C H23 ranges from 3.69 g to 8 g. Each hybrid plant under test had 138 and 254 fruit, while the comparison variety had 213 and 232 fruit. Compared to UNIB C H13, UNIB C H23, UNIB C H43, UNIB C H433, UNIB C H73, and comparator varieties, UNIB C H63 has the most fruit per plant—254—than any other variety (Table 4). When comparing varieties, UNIB C H63 outperforms TARO and LADO. The hybrids evaluated ranged from 1406 to 2845 fruit, and for the comparator variety, from 2095 to 2407 fruit, based on

the number of fruit characteristics per plot. With 2854 fruit per plot, UNIB C H63 had the most fruit and differed not appreciably from the TARO comparison variety. There were 138 to 254 fruits on each hybrid plant being tested, compared to 213 to 232 on the comparative variety. UNIB C H63 contains the most excellent fruit per plant—254—when compared to UNIB C H13, UNIB C H23, UNIB C H43 UNIB C H433, UNIB C H73, and comparator cultivars (Table 4). In comparison, UNIB C H63 performs better than TARO and LADO. Based on the number of fruit characteristics per plot, the hybrids under evaluation ranged from 1406 to 2845 fruit, and for the comparator variety, from 2095 to 2407 fruit. UNIB C H63 has the most fruit per plot—2854—and does not significantly differ from the TARO comparative variety. However, the number of fruits per plot was significantly different when compared with UNIB C H13, UNIB C H23, UNIB C H43, UNIB C H433, UNIB C H73, and the comparison variety LADO (Table 4). This means that UNIB C H63 is equivalent to the TARO comparison variety and superior to the LADO comparison variety. The number of fruits produced on a plant has a significant and positive correlation with the number of fruits per plot (r = 0.947), fruit weight per plant (r = 0.627), and fruit weight per plot (r = 0.531) (Table 6). This shows that the more fruit produced per plant, the greater the number of fruit per plot and the higher the weight of the fruit produced.

The range of fruit weight features for each hybrid plant under examination was 298.6 g to 733.9 g, whereas the comparator variety showed a range of 492.6 g to 518.3 g. Compared to the UNIB C H13 genotype, UNIB C H23 had the highest total fruit weight per plant, 733.9 g (12.23 tonnes/ha), which was not statistically significant. On the other hand, UNIB C H43, UNIB C H433, UNIB C H63, UNIB C H73, and the comparative varieties TARO and LADO showed a significantly different fruit weight per plant (Table 4). This indicates that UNIB C H23 is better than the LADO and TARO comparator variants. The correlation analysis's findings demonstrated a substantial and positive relationship between fruit weight per plant, weight per fruit (r = 0.563), number of fruits per plant (r = 0.627), and number of fruits per plot (r = 0.615) (Table 6, Figure 4).

Incidence and severity of PYLCV disease

A virus in chili plants is the cause of the disease known as *Pepper Yellow Curl Virus* (PYLCV). At 15% and 13%, respectively, the UNIB C H23 genotype exhibits the lowest incidence and severity of PYLCV illness. The LADO variant has the highest figures, with a disease incidence of 69% and disease severity of 47%. The incidence of PYLCV disease was substantially and adversely connected with fruit diameter (r = -0.482) and weight per fruit (r = -0.639) according to the results of the correlation analysis

(Table 6). This implies that plants that experience a minor disease assault will produce fruits with a significant fruit weight and a large fruit diameter.

Figure 4. Appearance of six varieties of hybrid chili peppers (UNIB C H13, UNIB C H23, UNIB C H43, UNIB C H433, UNIB C H63 dan UNIB C H73) and two comparison varieties (TARO dan LADO)

Table 5. Disease Incidence and Severity of PYLCV

Treatment	Incidence	Severity (%)
UNIB C H13	0.53	31
UNIB C H23	0.15	13
UNIB C H43	0.35	20
UNIB C H433	0.40	23
UNIB C H63	0.24	13
UNIB C H73	0.31	14
TARO	0.58	42
LADO	0.69	47

Table 6. Correlation analysis of the variables Growth, Yield, and PYLCV disease incidence and severity

	PH	SD	DH	FT	HA	CW	LL	LW	FL	DF	WF	NFP	NFO	WFP	WFO	Incidence PYLCV	Severity PYLCV
PH		0.412*	0.008 ns	-0.144 ns	-0.250 ns	0.377ns	0.562**	0.203 ns	-0.112 ns	0.542**	0.146ns	0.235 ns	0.286ns	0.192ns	0.315ns	-0.382ns	-0.344ns
SD			-0.404 ns	-0.254 ns	-0.400 ns	0.410*	0.572**	0.439*	0.054 ns	0.646***	0.451*	0.028 ns	0.026ns	0.212ns	0.411*	-0.346ns	-0.199ns
DH				0.116 ns	0.313 ns	-0.076ns	-0.059ns	-0.167 ns	0.110 ns	-0.207ns	-0.182ns	-0.069 ns	-0.039ns	-0.154ns	-0.196ns	0.347ns	0.228ns
FT					0.572**	-0.485*	-0.216ns	-0.092 ns	-0.517**	-0.236ns	-0.675***	-0.078 ns	-0.047ns	-0.701***	-0.685***	0.104ns	0.041ns
HA						-0.736***	-0.550**	-0.597**	-0.111 ns	-0.400ns	-0.456*	0.115 ns	0.152ns	-0.327ns	-0.295ns	0.194ns	0.187ns
CW							0.711***	0.552**	-0.122 ns	0.050ns	0.272ns	-0.134 ns	-0.159ns	0.125ns	0.178ns	-0.074ns	-0.155ns
LL								0.616**	-0.227 ns	0.569**	0.260ns	-0.125 ns	-0.177ns	-0.003ns	0.050ns	-0.303ns	-0.320ns
LW									-0.298 ns	0.398ns	0.103ns	-0.246 ns	-0.300ns	-0.103ns	-0.111ns	-0.136ns	-0.147ns
FL										0.050ns	0.782***	-0.186 ns	-0.122ns	0.468*	0.528**	-0.164ns	-0.152ns
DF											0.527**	-0.015 ns	0.073ns	0.236ns	0.379ns	-0.639***	-0.582**
WF												-0.202 ns	-0.145ns	0.563**	0.667***	-0.482*	-0.469*

NFP	0.947***	0.627**	0.531**	0.078ns	0.181ns
NFO		0.615**	0.572**	0.094ns	0.105ns
WFP			0.927***	0.014ns	-0.049ns
WFO				-0.112ns	--0.0.170ns
Incidence PYLCV					0.934***
Severity PYLCV					

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Information: TT = plant height, DBt = stem diameter, TD = dichotomous height, WB = flowering time, UP = harvest age, LK = canopy width, PD = leaf length, LD = leaf width, PB = fruit length, DBh, diameter fruit, BPB = weight per fruit, JBPT = number of fruit per plant, JBPP = number of fruit per plot, BBPT = weight of fruit per plant, BBPP = weight of fruit per plot, PYLCV incidence = incidence of Pepper yellow leaf curl virus, PYLCV incidence = incidence Pepper yellow leaf curl virus.

Discussion

Plant growth

Chili plants showed average and uniform growth. Rainfall during the study was still in a suitable range for chili growth. Suitable rainfall for chili cultivation ranges from 100-200 mm/month (Imtiyaz *et al*., 2017). Plant height, stem diameter, dichotomous height, canopy width, leaf length, leaf width, flowering time, harvest age, fruit length, fruit diameter, weight per fruit, number of fruit per plot, fruit weight per plant, fruit weight per plot, and PYLCV disease severity differed among the varieties tested.

The tallest plant variety is the UNIB C H23 chile cultivar. Compared to earlier tests, the chili plants in this one were taller. Genetic factors determine aspects of plant height. The result of crossing two parents is this hybrid. Supriyadi (2015) reports that the plant height of UNIB C H23 is 70.61 cm in histosol and 77.56 cm in ultisol soil. Fruit diameter and plant height positively correlated (r = 0.412). This implies that the stem diameter increases with plant height. It turns out that there is little correlation between plant height and the quantity and weight of fruit produced. According to Rahmayanti (2019), UNIB C H53 is the tallest plant, although UNIB C H65 has more fruits. Kirana (2017) states that the height range of hybrid plants is 87.0 - 109.6 cm. According to Wahyudi *et al*. (2023), the tested genotype F1074003 had a plant height of 76.03 cm, substantially different from the other genotypes but not from the comparison genotype Balebat. UNIB C H23 exhibits a greater stem diameter than TARO and LADO, the comparator varieties. Large stem diameters benefit generative and vegetative growth because they make the plant more robust and resilient to uprooting (Sunyoto *et al*., 2015). Fruit diameter (r = 0.646), weight per fruit (r = 0.451), and weight per plot (r = 0.411) are all closely correlated with stem diameter. Accordingly, a higher stem diameter might result in a larger fruit diameter, which raises the fruit weight values. Supriyadi (2015) found that the stem diameter of genotype C H23 is 8.51 mm. According to Kusmanto *et al*. (2015), the genotype F7015008-5 had the most significant values for stem diameter and plant height. F8120005-141-16-35-7-1 (7.90 mm) displayed the most oversized stem diameter (Gou *et al*., 2020).

The new hybrid chili produced by UNIB has a higher dichotomous height. Syukur *et al*. (2022) added that the dichotomous height measured in their research ranged from 15.00 to 34.57 cm at all planting locations. The short dichotomy causes the chili fruit to come into contact with mulch or soil and is prone to direct rain splashes, which can cause disease in the fruit (Rommahdi *et al*., 2015).

In the variable of canopy width, UNIB C H43 chilies outperform the comparative cultivars TARO and LADO. Planting distances can be calculated using the width of the plant canopy; the more comprehensive the canopy, the larger the planting distance that should be employed. According to Febriansyah (2013), chili plants have a canopy width ranging from 48 to 84 cm. With a canopy width of 79.61 cm, H43 is the genotype with the largest width. The genotype with the widest canopy, H43, is found in Simanjuntak (2013) and Supriyadi (2015), measuring 97 cm and 62.75 cm, respectively. Fatmawati *et al*. (2008) report that the IPB-CH2 hybrid's canopy width was 78.21 cm, whereas the duke reference variety measured 75.03 cm. According to Wahyudi *et al*. (2023), genotype F1074003 had the widest canopy, measuring 70.33 cm. Pedo *et al.* (2013) state that canopy width is a crucial factor in photosynthesis rate, indirectly influencing plant productivity.

The most considerable leaf length (8.2 cm) and leaf width (4.0 cm) are found in UNIB C H43. Genetic factors determine the leaf's length and breadth features. The genotypes that were tested had lanceolate and oval leaf morphologies, respectively. The length and width of lanceolate leaves differ from those of oval leaves. Because this trait is inherited from both parents, a genotype's leaf length and width are determined by the form of the leaves. The amount of soil fertility is one of the environmental elements that affect the properties of leaf length and width. Broader and longer leaves are typically found on more productive plants. The length and width of the leaves impact the leaf area, which is correlated with how much sunlight the leaves get, enhancing the plant's capacity for photosynthesis and indirectly influencing the plant's biomass. According to Santoso (2015), the UNIB C H43 genotype exhibited a leaf length of 5.95 cm in ultisol land and 8.58 cm in regosol land. According to Kusmanto (2015), the genotypes tested had leaf length values ranging from 6.4 to 11.7 cm. According to Wahyudi *et al*. (2023), the genotype Balebat exhibited the longest leaf (13.76 cm), with the genotypes Gada, F1374003, F 1074005, and F1074003 following suit. According to Santoso (2015), the leaf width of UNIB C H43 is 2.71 cm on ultisol land and 3.47 cm on regosol soil. The genotypes evaluated had leaf width values ranging from 2.7 to 4.1 cm, according to Kusmanto *et al*. (2015). Compared to other genotypes, the Balebat genotype has the widest leaf (5.27 cm), followed by the F1074003, F1374003, and Gada genotypes (Wahyudi *et al*., 2023).

Yield

The hybrids generated by UNIB blossom and harvest more quickly. This is advantageous since the plants that produce chilies blossom and harvest more

quickly, meeting market demand sooner. Plants that flower quickly will likewise harvest swiftly, as there is a significant and positive correlation between harvest time and flowering time (r = 0.572). Mastaufan (2011) asserts that faster flowering chili plants indicate a quicker onset of the generative cycle, which supports this. According to Yassi *et al*. (2020), there is a positive correlation between the time of flowering and harvesting; the earlier a plant flowers, the earlier it will be harvested. Harpenas and Dermawan (2010) assert that one of the best features of chile is its early flowering or fruiting. Genetic variables and genotype tolerance to various growing conditions mainly determine harvest age. Because of this, the response of each genotype to the harvest time for each type of soil varies. According to Alfian *et al*. (2013), environmental factors influence harvest age more than genetic ones, which have a lower heritability value. According to Wahyudi (2012), the genotypes tested had harvest ages ranging from 66.83 to 80.04 days after planting. Sugianto (2013) also mentioned that the genotype with the quickest harvest age, H23, is 66.50 HST. Kirana *et al*. (2017) also reported that the comparison was from 118.3 - 137.0 HST, whereas the mature fruit/harvest age range for hybrids was 119.7 - 138.7 days after planting. The Neno IPB genotype has a faster harvest and blooming period than any other genotype, according to Syukur *et al*. (2022).

One tested hybrid chili's weight, fruit diameter, and length differed. The longest and largest fruit is seen in UNIB C H23. According to Santoso (2015) research on regosol land, the UNIB C H23 genotype produced the most extended fruit (15.03 cm). This implies that the weight of the fruit produced increases with fruit length. Rahmayanti (2019) reported that the most extended fruit produced was the UNIB C H53 genotype (11.02 cm), and the maximum weight per fruit produced was the UNIB C H53 genotype, namely 2.65 g. According to Djayadiningrat *et al*. (2023), the evaluated hybrid chili fruit had a maximum length of 12.15 cm. The quality of chile fruit consumers can tolerate is determined by its length (Kirana *et al*., 2017). Longer fruiting chili plants yield heavier fruit, according to Ganefianti *et al.* (2006). Fruit length and weight per fruit (r = 0.782), weight per plant (r = 0.468), and weight per plot (r = 0.528) all showed a substantial and positive correlation. The quality of curly red chilies is categorized into three categories depending on fruit length, as per Indonesian National Standard (SNI) No. 01-4480-1998: quality I (>12–17 cm), quality II (10–<12 cm), and quality III (<10 cm). Thus, it can be said that the UNIB C H23 hybrid fruit length category is included in quality I according to the SNI quality requirements. Fruit diameter is strongly and positively connected with plant height (r = 0.542), stem diameter (r = 0.646), and weight per fruit (r = 0.527). This implies that the diameter and weight of the fruit increase with plant height and stem diameter. According to Santoso (2015), the C H23 genotype produced

fruits with the most oversized diameters—8.81 mm on regosol land and 8.83 mm on ultisol land. According to Syukur *et al*. (2010), IPB CH3's fruit diameter (14 mm) was more significant than all the comparator cultivars. When it comes to weight per fruit, UNIB C H23 performs better. According to Fahrurrozi and Ganefianti (2019), among all treatments, H23 cultivated without mulch had the highest average fruit weight (7.10 g), followed by H23 grown on rice straw mulch (5.90 g). Genetic factors impact the weight character of each fruit, with varied fruit sizes associated with each genotype. This occurs because, except for the male parent, all genotypes have distinct fruit sizes and originate from different parents (P3). Variations in the fruit weight features of each genotype utilized result from each genotype inheriting the traits of the two parents it is crossed with. Fruit length (r = 0.782), fruit diameter (r = 0.527), fruit weight per plant (r = 0.563), and fruit weight per plot (r = 0.667) all showed a substantial and positive correlation with fruit weight per fruit. This means that the longer the fruit and the wider the diameter of the fruit, the greater the weight of the fruit produced. According to Ganefianti *et al*. (2017), the UNIB C H23 hybrid outperformed other comparative types in terms of fruit length, diameter, weight per fruit, and weight per plant. In line with this statement, Sahid *et al*. (2020) added that the fruit's length and diameter greatly influence the chili fruit's weight.

The UNIB C H63 hybrid has the highest number of fruits per plant and number of fruits per plot. The number of fruits produced affects the weight of the plant's fruit (Sahid *et al*., 2022). The number of fruit produced on a plant has a significant and positive correlation with the number of fruit per plot (r = 0.947), the weight of fruit per plant (r = 0.627), and the weight of fruit per plot (r = 0.531) produced. This means that the more fruit produced per plant, the greater the number of fruit per plot and the higher the weight of the fruit produced. According to Situmorang *et al*. (2013), plant output is impacted by the total fruit weight of a plant, which increases with the quantity of fruits on the plant. Plants bearing a lot of fruit will yield a lot overall, according to Ganefianti *et al*. (2006). Numerous studies' findings also demonstrate a favorable and substantial relationship between yield components and fruit count (Ozukum *et al.*, 2019; Negi amd Sharma, 2019; Usman *et al.*, 2017; Lavinia *et al*., 2013).

The hybrid variety UNIB C H23 has the highest total fruit weight per plant and fruit weight per plot, namely 733.9 g (12.23 tons/ha. This aligns with the description: UNIB C H23 weighs fruit ranging from 220.52 g to 752.80 g. Next, the genotypes that produced fruit weight per plant from high to low were UNIB C H13 (588.29 g = 9.80 tons/ha), comparison variety LADO (518.38 g = 8.63 tons/ha), comparison variety TARO. (492.38 g = 8.20 tons/ha), UNIB C H63 (491.41 g = 8.18 tons/ha), UNIB C H73 (401.12 g = 6.68 tons/ha), UNIB C H433 (349.14 g = 5 .81 tonnes/ha), and UNIB C H43 (298.60 g = 4.97 tonnes/ha)

Ganefianti *et al* (2017) stated that the C H23 hybrid had higher fruit weight per plant than other comparison varieties. The average weight of UNIB hybrid chili cuttings was reported by Ganefianti *et al*. (2022) to be between 21.21 and 59.50 grams. The H2 optimistic hybrid produced the highest average fruit weight per plant of 226.24 g, which was not substantially different from H4, according to Djayadiningrat *et al*. (2023). Dwiguna UNIB had the highest fruit weight per plant (305 g) and the highest fruit weight per plot (7920.59 g), according to Ganefianti *et al*. (2019). Fruit weight and the quantity of fruits on a plant affect chili productivity (Yang *et al*., 2017). Fruit weight per plant had a substantial and positive association (r = 0.563) with weight per fruit, number of fruits per plant (r = 0.627), and number of fruits per plot (r = 0.615) according to the correlation analysis results. This implies that fruit weight per plant will increase directly to fruit weight and production. Genetic variables can affect the fruit weight of plants. In addition, the weight of the fruit and environmental variables influence a plant's yield. Positive results are correlated with a growing environment that is both fertile and fits the requirements for producing chili plants.

Incidence and severity of PYLCV disease

The UNIB C H23 genotype has the lowest incidence of PYLCV disease, namely 13%. The LADO variety has the highest disease severity, namely 47%. Based on the results of correlation analysis, the incidence of PYLCV disease is significantly and negatively correlated with weight per fruit (r = -0.639) and fruit diameter (r = -0.482). This means that the fewer plants are attacked by disease, the higher the fruit weight and the larger the diameter of the fruit produced. Sidik *et al.* (2023) stated that the age of the plant when infection occurs is thought to increase the risk of severe symptoms accompanied by stunting. Pandey *et al*. (2021) added that the earlier the plant is infected, the more significant the impact of the damage. This causes the plant not to bear fruit, or the fruit is small and damaged and cannot even be harvested. PYLCV illness severity The incidence of PYLCV disease showed a significant negative correlation with fruit diameter (r = -0.469) and weight per fruit (r = -0.582). This indicates that the fruit's weight and diameter increased with decreasing disease attack scores on the plant. A strong and positive correlation was found between the incidence of PYLCV disease in plants and its severity. This suggests that the higher the incidence of PYLCV disease, the severity of PYLCV disease likewise increases. According to Ganefianti *et al.* (2008), the disease severity value increases with the percentage of symptomatic plants and symptom score. Comparision to other hybrids examined and reference types, UNIB C H23, which was grown in

the lowlands, was superior. Growth (plant height, stem diameter, canopy width, leaf length), yield (flowering time, harvest time, fruit length, fruit diameter, fruit weight per fruit, fruit weight per plant, and fruit weight per plot), and the lowest incidence and severity of PYLCV disease (13% and 15%, respectively) are the benefits of the UNIB C H23 hybrid. The potential yields of this hybrid are 12.23 tons/ha. UNIB C H63 is superior in growth (plant height, canopy width), yield (fruit diameter, number of fruit per plant, number of fruit per plot), and disease severity (13%), with potential yields reaching 8.18 tonnes/ha. UNIB C H13 is superior in growth (dichotomous height, canopy width), yield (flowering time, harvest age, fruit length, fruit weight per plant), and disease severity (31%), with potential yields reaching 9.80 tonnes/ Ha. 4. UNIB C H73 excels in growth (dichotomous height), yield (fruit length, fruit diameter), and disease severity (14%), with potential yields reaching 6.68 tonnes/ha. UNIB C H73 excels in growth (dichotomous height), yield (fruit length, fruit diameter), and disease severity (14%), with a potential yield of 6.68 tonnes/ha. UNIB C H433 has a potential yield of 5.81 tonnes/ha and a relatively low disease severity level of 23%.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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