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Agronomic Performance of IPB's Red Chili Pepper (*Capsicum annuum* L.) Lines in Different Environments in Bogor, West Java, Indonesia

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Abstract

Our study aims to determine the agronomic performances of the red chili pepper genotypes developed by the IPB University as compared to the existing commercial varieties. The study was conducted from June 2019 to April 2020 in the Leuwikopo and Tajur experimental fields, IPB University, Bogor, West Java, Indonesia. Leuwikopo and Tajur location differs in the soil type and environments. The experiments at Leuwikopo were conducted twice, once during the dry season, and once during the rainy season. The experiments were set up in a completely randomized block design with a single factor, i.e. sixteen red chili pepper genotypes, replicated three times in three different environments. The 11 genotypes evaluated were F8120005-141-16-35-1-3, F8120005-141-16-35-1-4, F8120005-141-16-35-7-1, F8120005-241-2-9-4- 4, F7120005-120-7-1-7-8-1-2, F6074-7-4-2-1, F4074136-2-3, F474077-1, F474035-2-1, F474035-2, F4136074-1-4; these lines were compared to five commercial chili varieties, "Laris", "Gada" F1, "Kastilo" F1, "Anies IPB", "Seloka IPB". Measurements were conducted on time to harvest, fruit length, fruit diameter, weight per fruit, number of fruits per plant, fruit weight per plant, and productivity. The results showed that the curly and large red chili pepper genotypes had similar agronomic performances to the control curly variety "Laris" and "Kastilo" F1, and "Anies IPB", "Seloka IPB", or "Gada" F1 as control variety for the large chili. Our study demonstrated that all large and curly red chili pepper lines developed in IPB University have excellent potentials to be commercialized into superior varieties.

Keywords: curly fruit chili, diversity, Leuwikopo, Tajur

Introduction

Chili pepper (*Capsicum annuum* L.) is one of the important horticultural crops in Indonesia. The planting area of chili in 2020 was 133,729 hectares, the largest of vegetable crops in Indonesia (BPS, 2020). Chili is the main contributor to the inflation increase in the volatile foods category in Indonesia, which happened in September and October 2016 (Bank Indonesia, 2016). According to the Central Statistics Bureau (2019), the national chili productivity in 2019 was 9.10 tons per hectare, which is far below the potential productivity of 20 tons per hectare (Syukur et al., 2010). Therefore, it is important to continuously improving the genetics and production system to have higher yields (Syukur et al., 2010).

The success of a breeding program depends on the genetic resource variabilities; and genetic variability occurs through crosses between two parents. Parents of pure lines or a homozygous will produce uniform heterozygous F1 derivatives, and segregation will occur in the F2 generation (Kirk et al., 2012). According to Zecevic et al. (2011), the F2 generation is the generation that has the maximum recombination of genes, so the F2 generation is the best choice for selection in plant breeding. The chili pepper lines used in this study were developed by pedigree selection.

The chili in Indonesia is mostly consumed fresh, or as an important spice for cooking. Ideally, chili is cultivated in various regions to obtain fresh produce and to shorten the transportation time from the production area and the markets and consumers.

According to Syukur et al. (2015) a superior crop would still need optimal environments to have high yields. On the other hand, lower yield varieties still

cannot produce high yields even when an optimal environment had been provided, as plant phenotype is a result of the interaction between genetic and non-genetic factors, which is represented by the environment. The objective of our study is to determine how red chili pepper genotypes and the environment affect their growth and yield of red chili pepper genotypes developed at IPB University.

Materials and Methods

The study was conducted in June 2019 to April 2020 in three different environments: experimental field at IPB-Leuwikopo during the dry season (Leuwikopo 1) and during rainy season (Leuwikopo 2), and at Tajur experimental field. Leuwikopo has an altitude of 230 m above the sea level (asl), whereas Tajus is 320 m asl. All study areas are located in the Bogor Regency, West Java, Indonesia. Post-harvest handling was conducted at the Plant Breeding Education Laboratory of the Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University.

A total of 16 genotypes of curly-fruit chili and large-fruit chili pepper and hybrid red chili peppers were tested; 11 of them are genotypes developed at IPB University. The experimental genotypes consist of five open-pollinated curly-fruit red chili pepper: F8120005-141-16-35-1-3 (G1), F8120005-141-16-35-1-4 (G2) F8120005-141-16-35 -7-1 (G3), F8120005-241-2-9-4-4 (G4), F7120005-120-7-1-7-8-1-2 (G5), and six open-pollinated large red chili pepper: F4074136-2-3 (G8), F474077-1 (G9), F474035-2-1 (G11), F474035-2 (G12), F4136074-1-4 (G14). The 11 lines were compared to five control varieties which are the commercially grown chili varieties in Indonesia: two were hybrid varieties of curly-fruit red chili pepper "Laris" and "Kastilo", and three large fruit red chili pepper hybrid varieties "Anies IPB", "Seloka IPB" and "Gada" F1.

Experiments were set up in a randomized complete block design with 16 genotypes and replicated three times. Each plot is 1 m x 5 m with a bed height of 20 cm, and a distance between beds of 50 cm. Twenty chili seedlings were planted on each plot. Soil in the plots was treated with manures and agricultural lime at the standard dosage according to the location. Basal fertilizers consist of 150 kg.ha^{-1} urea, 300 kg.ha^{-1} SP-18, and 200 kg.ha^{-1} KCl were applied, then the beds were covered with silver black mulch. Planting holes were made with a distance of 50 cm x 50 cm within a row, with a depth of 20 cm. Seedlings were transferred to plots 21–24 days after germination or when they had 3-4 true leaves. Harvesting was conducted when 75% of the population had reached fruit ripening. Fruits are considered ripe and ready for harvest when 70% of its structure was red in color.

Growth measurements were conducted on 10 randomly selected sample plants in each plot with reference to Descriptors for Capsicum (IPGRI, 1995): harvest age (days after sowing, DAS), fruit length (cm), fruit diameter (mm), number of fruits per plant, weight per fruit (g), fruit weight per plant (g), and productivity (t.ha^{-1}), which was estimated using the following corrected equation:

(Fruit weight per plant x 26670 plants.ha^{-1}) x 80% of the survived plants per experimental unit)/ 1,000,000

Data were analyzed using variance analysis, followed by a combined analysis of the three environments using the PBSTAT (Plant Breeding Statistics) version 2.2. For the characters with significant effects for genotype, environment, or genotype x environment, further tests were carried out using the Tukey honest real difference test for all characters. except for productivity that used Duncan Multiple Range test.

Results and Discussion

Effect of Genotypes and Environment on Growth and Yield of Red Chili Pepper

All sixteen lines of red chili pepper vary significantly in their time to harvest, fruit size (length and diameter) and weights, number fruits per plant, and productivity (Table 1). Different growing environments had significant effects on most of the plant characters of the 16 lines, except for the fruit weight per plant and productivity. Genotype and environment interaction significantly affected all yield components (Table 1). The significant differences in the growth performance and productivity of the different lines represents high genetic diversities and significant differences in the genetic background of each line (Santos et al., 2014; Syukur et al., 2011).

The interaction between genotype and environment (G x E) significantly affected all the yield components (Table 1), demonstrating that the quantitative characteristics of the red chili pepper genotypes vary between environments. According to Sa'diyah et al. (2013), the broad phenotype variability is influenced by the genetic and environmental variabilities. Plants with different genotypes could have different phenotypes/appearances when planted in the same environmental condition (Nilahayati and Putri, 2015). The significant effect of environmental genotype interactions (G × E) for all characters indicates a differential genotype responses in the environment for

Table 1. Recapitulation analysis of the yield components of 16 genotypes of red chili pepper in Tajur and Leuwikopo environments

Characters	F probability			G	E	G x E
	LW 1	Tajur	LW 2			
Harvest age	4.36**	3.38**	3.92**	5.90**	14.59**	3.47**
Fruit length	9.74**	8.51**	17.85**	26.31**	25.40**	2.15**
Fruit diameter	8.60**	12.84**	41.24**	42.26**	45.34**	1.87*
Weight of per fruit	6.11**	6.48**	32.20**	27.58**	16.69**	1.97**
Number of fruits per plant	6.23**	14.26**	5.68**	8.19**	5.14*	7.60**
Weight of fruits per plant	9.31**	3.52**	5.39**	7.69**	4.24tn	4.60**
Productivity	14.30**	3.52**	5.39**	8.64**	4.24tn	5.20**

Notes: LW (Leuwikopo), G (Genotype), E (environments), G x E (Genotype x Environments);
* significant at α <0.05; ** highly significant at α<0.01.

these traits (Sivakumar et al., 2017). The significant interaction of genotype and environmental showed differences in the adaptability of each line (Thanki et al., 2010). Genotype and environment interaction are associated with the development of varieties that demonstrates stability of the characters when planted in different environments (Syukur et al., 2018).

The time to harvest of chili pepper lines in the three environments ranged from 80.28 to 89.98 days (Table 2). Early harvest is one of the desired traits. All the IPB curly fruit chilies (G1-G5) showed significantly shorter time to harvest than the two control varieties, “Laris” and “Kastilo” F1 hybrid. However, in the large-fruit chili peppers the harvest age of the control was significantly shorter than that of curly-fruit chili lines (Table 2). All IPB large fruit chili (G8-G14), except for G9, had similar harvest age as the control large chili varieties “Anies IPB”, “Seloka IPB”, and “Gada” F1 hybrids, whereas the large fruit chili genotype G9 has a longer harvest age than other chili lines in the study. The longer time to harvest could be due to the late-formation of the fruit. The efficiency in harvesting can be related to plant height; for example, tall rice

Table 2. Days to harvest of the 16 genotypes of red chilli pepper in Tajur and Leuwikopo environments

Genotypes	Leuwikopo 1	Tajur	Leuwikopo 2	Average of genotypes
	..... (dap)			
G1	77.82def	81.00a	87.87a	82.23bcd
G2	75.53def	81.33a	90.23a	82.37bcd
G3	80.87bcdef	81.33a	89.07a	83.76bcd
G4	73.87ef	81.00a	87.10a	80.66cd
G5	75.30def	82.67a	85.43a	81.13bcd
“Laris”	91.43ab	85.67a	92.83a	89.98a
“Kastilo” F1	88.83abc	81.67a	89.50a	86.67abc
G8	72.30f	81.00a	87.53a	80.28d
G9	94.07a	82.33a	85.47a	87.29ab
G10	85.90abcd	81.00a	87.20a	84.70abcd
G11	83.73abcde	81.67a	87.33a	84.24abcd
G12	73.87ef	81.67a	85.57a	80.37d
G14	75.27def	81.33a	85.03a	80.54cd
“Gada” F1	73.07ef	82.33a	86.03a	80.48cd
“Anies IPB”	74.10ef	82.00a	85.97a	80.69cd
“Seloka IPB”	79.73cdef	82.33a	83.57a	81.88bcd
Average of environments	79.73B	81.90B	87.23A	82.95

Note: Values followed by the same lowercase letter in each environment column and the mean genotype, and the same capital letter on the environmental average row shows no significant differences based on the Tukey test at α <0.05.

varieties are prone to lodging, but short-posture varieties are more challenging to harvest (Gunarsih, 2016).

Fruit length of chili in the three different environments ranges from 10.68 cm to 16.55 cm (Table 3). All IPB curly-fruit chili (G1-G5) produced significantly longer fruits than the control varieties, whereas the IPB large fruit chili (G8-G14) had similar fruit length to the control ("Anies IPB", "Seloka IPB", and "Gada" F1 hybrids), except for G12, which had significantly longer fruit (14.99 cm) than the control large chili (Table 3).

The fruit diameter of the different chili genotypes in the three environments ranged from 7.33 to 10.56 mm for the curly-fruit,s and 11.74 to 13.48 mm for the large-fruit chilli (Table 4). The fruit diameter of the IPB curly-fruit chili (G1-G4) was not significantly different from those of the control varieties, "Laris" and "Kastilo". G5, however, had a significantly larger fruit diameter compared to "Laris". For the large-fruit chili, most of the IPB genotypes (G8-G14) produced fruit with a diameter that was similar to the control varieties "Anies IPB", "Seloka IPB", and "Gada" F1 hybrids. G11, however, had fruits with a significantly greater diameter than the control large-fruit chili Anies. According to Sujitno and Dianawati (2015) plant height, fruit diameter, and fruit length affect fruit production. In addition, Sharma et al. (2010) stated that fruit length positively correlate with fruit weight per plant.

The weight per fruit of the chili genotypes from three locations ranged from 3.87 to 7.25 g for the curly-fruit chilies, and 8.32 to 10.70 g for the large-fruit chilies (Table 5). The weight per fruit of all IPB curly-fruit genotypes (G1-G5) was significantly heavier than the two control varieties, "Laris" and "Kastilo" F1, and among all curly-fruit chilies, G5 was the heaviest (Table 5). However, in the large chilies, the weight per fruit of all genotypes was not significantly different.

The number of fruits per plant in the chili genotypes ranged from 73.86 to 136.75 (Table 6). The average number of fruits per plant of the IPB curly-fruit chili (G1, G2, G3, G5) and "Laris" were significantly lower than those of the "Kastilo" F1 hybrid and G4 (Table 6). For the large-fruit chili, some IPB-developed lines (G9-G12) did not produce as many fruits as the control varieties, whereas G8 and G14 produced a similar number of fruits per plant to the control varieties. Environmental factors affect the number of fruits per plant (Table 5). However, Asnijar (2013) stated that

Table 3. Fruits length (cm) of 16 genotypes of red chili pepper in Tajur and Leuwikopo environments

Genotypes	Fruit length (cm)			
	Leuwikopo 1	Tajur	Leuwikopo 2	Average of genotypes
G1	13.28^{ab}	17.42^{ab}	16.86^{ab}	15.85^{ab}
G2	12.37^{abc}	15.92^{abcd}	15.60^{abcd}	14.63^{bcd}
G3	13.41^{a}	18.24^{a}	17.98^{a}	16.55^{a}
G4	11.55^{abc}	14.81^{cdef}	14.65^{bcd}	13.67^{cde}
G5	11.28^{abc}	15.13^{bcde}	14.98^{bcd}	13.80^{cde}
"Laris"	11.00^{abc}	13.50^{cdefg}	14.48^{bcde}	12.99^{efg}
"Kastilo" F1	10.88^{abc}	13.87^{cdefg}	13.14^{de}	12.63^{efg}
G8	12.25^{abc}	13.53^{cdefg}	14.53^{bcd}	13.44^{def}
G9	10.53^{c}	13.69^{cdefg}	14.61^{bcd}	12.94^{efg}
G10	9.96^{c}	12.69^{efg}	13.57^{cde}	12.08^{fgh}
G11	10.71^{bc}	13.77^{cdefg}	14.34^{bcde}	12.94^{efg}
G12	13.15^{ab}	16.04^{abc}	15.78^{abc}	14.99^{bc}
G14	10.78^{bc}	11.72^{gh}	13.21^{cde}	11.90^{gh}
"Gada" F1	11.19^{abc}	12.31^{fgh}	14.26^{bcde}	12.59^{efg}
"Anies IPB"	11.04^{abc}	13.38^{defg}	13.27^{cde}	12.56^{efg}
"Seloka IPB"	10.40^{c}	9.76^{h}	11.88^{e}	10.68^{h}
Average of environments	11.49B	14.11A	14.57A	13.39

Note: Values followed by the same lowercase letter in each environment column and the mean genotype, and the same capital letter on the environmental average row shows no significant differences based on the Tukey test at α <0.05.

Table 4. Fruits diameter (mm) of 16 genotypes of red chili pepper in Tajur and Leuwikopo environments

Genotypes	Fruit diameter (mm)			
	Leuwikopo 1	Tajur	Leuwikopo 2	Average of genotypes
G1	6.97^{fg}	8.62^{de}	8.76^{de}	8.11^{ef}
G2	7.34^{efg}	9.13^{de}	9.58^{de}	8.68^{ef}
G3	8.02^{cdefg}	9.50^{cde}	9.45^{de}	8.99^{de}
G4	7.70^{efg}	9.38^{cde}	10.14^{cde}	9.07^{de}
G5	8.90^{bcdefg}	11.36^{bcd}	11.25^{bcd}	10.50^{cd}
“Laris”	6.64^{g}	7.12^{e}	8.23^{e}	7.33^{f}
“Kastilo” F1	7.98^{defg}	8.06^{e}	9.08^{de}	8.37^{ef}
G8	10.02^{abcde}	12.18^{bc}	13.07^{ab}	11.75^{bc}
G9	11.04^{ab}	12.76^{b}	12.92^{abc}	12.24^{ab}
G10	10.86^{abc}	12.46^{b}	13.31^{ab}	12.21^{ab}
G11	12.15^{a}	13.26^{ab}	15.04^{a}	13.48^{a}
G12	10.70^{abcd}	15.69^{a}	13.19^{ab}	13.19^{ab}
G14	10.84^{abc}	11.24^{bcd}	13.15^{ab}	11.74^{bc}
“Gada” F1	11.17^{ab}	12.99^{ab}	14.80^{a}	12.99^{ab}
“Anies IPB”	10.59^{abcd}	13.15^{ab}	13.67^{ab}	12.47^{ab}
“Seloka IPB”	9.67^{abcdef}	13.15^{ab}	14.68^{a}	12.50^{ab}
Average of environments	9.41B	11.25A	11.89A	10.85

Notes: Values followed by the same lowercase letter in each environment column and the mean genotype, and the same capital letter on the environmental average row shows no significant differences based on the Tukey test at α<0.05.

Table 5. Weight of per fruits (g) of 16 genotypes of red chili pepper in Tajur and Leuwikopo environments

Genotypes	Fruit weight (g)			
	Leuwikopo 1	Tajur	Leuwikopo 2	Average of genotypes
	….....(gram)….....			
G1	4.02^{abc}	7.54^{cdef}	6.69^{e}	6.08^{ef}
G2	3.70^{bc}	7.14^{cdef}	6.75^{de}	5.86^{efg}
G3	4.66^{abc}	8.48^{bcde}	7.13^{cde}	6.76^{de}
G4	3.80^{abc}	6.98^{def}	6.75^{de}	5.84^{efg}
G5	4.39^{abc}	9.06^{bcd}	8.30^{bcde}	7.25^{cde}
“Laris”	2.83^{c}	4.05^{f}	4.74^{e}	3.87^{g}
“Kastilo” F1	4.17^{abc}	4.95^{ef}	4.87^{e}	4.66^{fg}
G8	7.38^{a}	10.21^{abcd}	10.63^{abc}	9.41^{ab}
G9	5.95^{abc}	10.70^{abc}	10.36^{abc}	9.00^{abc}
G10	6.00^{abc}	9.91^{abcd}	10.35^{abcd}	8.75^{abcd}
G11	6.90^{ab}	11.57^{ab}	12.94^{a}	10.47^{a}
G12	7.36^{a}	13.15^{a}	11.59^{ab}	10.70^{a}
G14	6.16^{abc}	8.37^{bcde}	10.43^{abc}	8.32^{bcd}
“Gada” F1	6.89^{ab}	10.44^{abcd}	13.09^{a}	10.14^{ab}
“Anies IPB”	6.12^{abc}	11.38^{ab}	11.85^{ab}	9.78^{ab}
“Seloka IPB”	5.52^{abc}	9.27^{bcd}	11.21^{ab}	8.67^{abcd}
Average of environments	5.36B	8.95A	9.23A	7.85

Notes: Values followed by the same lowercase letter in each environment column and the mean genotype and the same capital letter on the environmental average row shows no significant differences based on the Tukey test at α < 0.05.

Table 6. Number of fruits per plant of 16 genotypes of red chili pepper in Tajur and Leuwikopo environments

Genotypes	Number of fruits per plant			
	Leuwikopo 1	Tajur	Leuwikopo 2	Average of genotypes
	….....(fruits)….....			
G1	102.11^{def}	149.47^{a}	123.10^{ab}	124.89^{ab}
G2	109.52^{cdef}	155.73^{a}	102.40^{ab}	122.55^{ab}
G3	100.63^{def}	78.60^{bc}	108.17^{ab}	95.80^{bcde}
G4	182.38^{a}	125.20^{ab}	102.67^{ab}	136.75^{a}
G5	128.31^{abcde}	108.47^{abc}	112.77^{ab}	116.51^{abc}
“Laris”	118.98^{bcdef}	67.80^{bc}	116.57^{ab}	101.11^{abcde}
“Kastilo” F1	134.39^{abcde}	143.67^{a}	128.70^{a}	135.59^{a}
G8	155.04^{abcd}	60.90^{c}	95.28^{ab}	103.74^{abcd}
G9	83.58^{ef}	58.23^{c}	79.77^{ab}	73.86^{de}
G10	72.57^{ef}	100.23^{abc}	77.43^{ab}	83.41^{cde}
G11	65.77^{f}	62.10^{c}	68.23^{ab}	65.37^{e}
G12	165.40^{abc}	58.03^{c}	62.50^{b}	95.31^{bcde}
G14	153.90^{abcd}	73.60^{bc}	78.53^{ab}	102.01^{abcd}
“Gada” F1	176.38^{ab}	63.50^{bc}	85.33^{ab}	108.40^{abcd}
“Anies IPB”	185.83^{a}	65.60^{bc}	77.30^{ab}	109.58^{abcd}
“Seloka IPB”	190.12^{a}	53.77^{c}	75.17^{ab}	106.35^{abcd}
Average of environments	132.80A	89.06A	93.37A	105.08

Notes: Values followed by the same lowercase letter in each environment column and the mean genotype, and the same capital letter on the environmental average row shows no significant differences based on the Tukey test at $\alpha < 0.05$.

in addition to environmental factors, plant growth and production are also influenced by the genetic potential of a variety. Previously, Syukur et al. (2010) reported that several parameters of the chili growth and production are known to be more determined by genetic factors than by the environment.

The average fruit weight of the chili genotypes in the three environments ranged from 227.02 to 626.87 g per plant (Table 7). All the IPB curly-fruit chili (G1-G5) had greater fruit weight per plant than the control varieties “Laris” and “Kastilo” F1. The fruit weight per plant of all IPB large-fruit chili (G8-G14) was similar to those from the control varieties. Fruit weight character is a quantitative character that is influenced by environment. Geneva et al. (2018) stated that planting in areas with different agro-climates would significantly impact yield characteristics, including fruit size. Thus, each genotype might have a different yield potential according to the genetical make up and the plant’s ability to adapt to its environment. Genotype and environment interacted in affecting fruit weight per plant, showing that genotypes with high yield potential at specific locations do not necessarily mean that the yield would remain high in other locations. In other words, the performance of a particular genotype is significantly influenced by various environmental conditions (Lestari et al., 2010).

Genotypic factors significantly influenced the average chili production per hectare (Table 1). The chili’s average productivity in the three environments ranged from 8.78 to 10.54 t. ha^{-1} (Table 8), whereas the average national chili productivity is 9.10 t.ha^{-1} (BPS, 2019). According to Agastya et al. (2017), the low red chili pepper production is caused mainly by pests, plant diseases, and weeds. Dalimunthe et al. (2015) and Dewi et al. (2016) also stated that a vector of viruses from the Caulimoviridae and Luteoviridae families could significantly reduce chili yields (Kanakala and Ghanim, 2016), i.e. up to 58% in the Sukada et al. (2014) study. However, pest and diseases were all under control in this study. The productivity of the red chili pepper (Table 8) and the fruit size of the IPB lines (Tables 3 and 4) were not significantly different from the control varieties. Therefore, the IPB curly and large fruit red chili pepper have excellent potentials to be further developed into superior varieties.

Table 7. Weight of fruits per plant (g) of 16 genotypes of red chili pepper in Tajur and Leuwikopo environments

Genotypes	Fruit weight per plant (g)			Average of genotypes
	LW 1	Tajur	LW 2	
	…….(gram)…….			
G1	227.16^{de}	619.49^{ab}	535.21^{abcd}	460.62^{bc}
G2	245.78^{cde}	630.92^{a}	464.35^{bcd}	447.01^{bc}
G3	246.85^{cde}	393.46^{abc}	506.82^{abcd}	382.37^{cd}
G4	365.78^{bcde}	572.59^{ab}	491.73^{abcd}	476.70^{abc}
G5	341.29^{bcde}	544.72^{ab}	680.46^{abc}	522.15^{abc}
“Laris”	158.80^{e}	151.96^{c}	370.29^{d}	227.02^{d}
“Kastilo” F1	293.08^{bcde}	418.99^{abc}	425.70^{cd}	379.26^{cd}
G8	489.43^{abcd}	405.00^{abc}	746.77^{a}	547.07^{ab}
G9	313.91^{bcde}	341.33^{bc}	605.07^{abcd}	420.11^{bc}
G10	242.87^{cde}	544.55^{ab}	623.60^{abcd}	470.34^{abc}
G11	246.13^{cde}	423.05^{abc}	651.03^{abcd}	440.07^{bc}
G12	555.08^{ab}	409.09^{abc}	508.88^{abcd}	491.02^{abc}
G14	461.40^{abcd}	399.99^{abc}	555.71^{abcd}	472.36^{abc}
“Gada” F1	704.14^{a}	439.94^{ab}	736.53^{ab}	626.87^{a}
“Anies IPB”	549.87^{ab}	355.36^{abc}	691.88^{abc}	532.37^{abc}
“Seloka IPB”	510.79^{abc}	352.12^{abc}	625.83^{abcd}	496.24^{abc}
Average of environments	372.02	437.66	576.24	461.97

Notes: Values followed by the same lowercase letter in each environment column and the mean genotype and the same capital letter on the environmental average row shows no significant difference based on the Tukey test at $\alpha < 0.05$.

Table 8. Productivity (t.ha^{-1}) of 16 genotypes of red chili pepper in Tajur and Leuwikopo environments

Genotypes	Productivity (t.ha^{-1})			Average of genotypes
	Leuwikopo 1	Tajur	Leuwikopo 2	
	…….(t. ha^{-1})…….			
G1	4.85^{ef}	13.22^{ab}	11.42^{abc}	9.83^{bcd}
G2	5.24^{def}	13.46^{a}	9.91^{bc}	9.54^{bcd}
G3	5.27^{def}	8.39^{abcd}	10.81^{abc}	8.16^{cde}
G4	7.80^{bcdef}	12.22^{abc}	10.49^{abc}	10.17^{abcd}
G5	7.28^{bcdef}	11.62^{abc}	14.52^{ab}	11.14^{abcd}
“Laris”	3.39^{f}	3.24^{d}	7.90^{c}	4.84^{e}
“Kastilo” F1	5.48^{def}	8.94^{abcd}	9.08^{bc}	7.83^{de}
G8	10.44^{abcde}	8.64^{abcd}	15.93^{a}	11.67^{ab}
G9	6.70^{cdef}	7.28^{cd}	12.91^{abc}	8.96^{bcd}
G10	5.18^{def}	11.62^{abc}	13.31^{abc}	10.04^{bcd}
G11	5.25^{def}	9.03^{abc}	13.89^{ab}	9.39^{bcd}
G12	11.84^{abc}	8.73^{abcd}	10.86^{abc}	10.48^{abcd}
G14	9.66^{abcde}	8.53^{abcd}	11.86^{abc}	10.02^{bcd}
“Gada” F1	15.02^{a}	9.39^{abc}	15.71^{a}	13.37^{a}
“Anies IPB”	10.92^{abcd}	7.58^{bcd}	14.76^{ab}	11.09^{abcd}
“Seloka IPB”	12.67^{ab}	7.51^{bcd}	13.35^{abc}	11.18^{abc}
Average of environments	7.94	9.34	12.29	9.86

Notes: Values followed by the same lowercase letter in each environment column and the mean genotype, and the same capital letter on the environmental average row shows no significant difference based on the DMR test at $\alpha < 0.05$.

Conclusion

The growth performance of the 11 IPB-developed red chili pepper, as reflected by the time to harvest, fruit length, fruit diameter, weight per fruit, number of fruits per plant, fruit weight per plant, and their productivity, are influenced by the intrinsic factor (their genotype), the extrinsic factors (environments), and the interaction of both genotype and environment. The IPB curly-fruit (G1-G5) and the large-fruit lines (G8-G14) had a similar or better performances than the control curly-fruit "Laris" and "Kastilo" F1, "Anies IPB", "Seloka IPB", and to the large-fruit control "Gada" F1. Therefore, all of the IPB large and curly-fruit red chili pepper lines have great potentials to be developed into superior varieties.

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