Indonesian Journal of Agronomy

ISSN 2085-2916 | e-ISSN 2337-3652
Indonesian J. Agron., *51*(1), 134-145, April 2023
DOI: https://dx.doi.org/10.24831/ija.v51i1.45161

Research Article

Agronomic responses of four garlic genotypes in two different locations

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Edited by:
Siti Marwiyah

Received:
30 December 2022
Accepted:
24 March 2023
Published online:
11 May 2023

Citation:
Aswani, N., Azmi, C., Cartika, I., Basuki, R. S. & Harmanto (2023). Agronomic Response of Four Garlic Genotypes in Two Different Locations. *Indonesian Journal of Agronomy, 51*(1), 134-145

ABSTRACT

Agronomic performance of garlic is speculated strongly affected by genotype × environment interaction, however, interaction evaluation is rarely studied in Indonesia. This research aimed to study the agronomic response of four garlic varieties in two different locations. The research was conducted from April to December 2021 using Lumbu Putih, Lumbu Hijau, Lumbu Kuning, and Tawangmangu Baru genotypes grown in two locations, i.e., Lembang (1250 m asl) and Ciwidey (1200 m asl), Bandung, West Java using randomized complete block design with three replications. Results showed that genotypes × locations interaction was found for traits: plant height, pseudo-stem stem diameter, number of stomata, weight, and diameter of fresh and dried bulbs. Chlorophyll content (SPAD value) depends on genotype, height of fresh bulbs and percentage of weight loss depending on location, while number of leaves was independently affected by genotype and location. Lumbu Kuning produced the highest average fresh weight with considerable differences in both locations (Lembang: 52.01 g, Ciwidey: 31.87 g) and also had the highest weight of dry bulb when planted in Lembang (24.65 g). Pearson's correlation showed that the strongest positive correlation (r=0.91) was found between the weight of the fresh bulb and pseudo-stem diameter when garlic genotypes were planted in Ciwidey. The present study implies the importance to select suitable genotypes for a particular location.

Keywords: genotype, environment, interaction, SPAD value, stomata, weight loss

INTRODUCTION

Garlic (*Allium sativum* L.) is one of the important species of Allium. It is also a highly consumed spice after chili and shallot in Indonesia. Garlic thrives on sandy loam or loam soils with good drainage and high soil organic content at 900–1,200 m above sea level with temperatures ranging from 12 to 24 °C (Diriba-Shiferaw, 2016). However, Indonesian garlic productivity is still low, as a result, national production only supplies 5-15% of domestic demand (Adila et al., 2022).

A study on genotype × environment interactions is necessary for measuring the potential yield of existing varieties in different environments (Teressa et al., 2021). It is well known that some genotypes prefer a specific environment or are widely adapted to several environments (Thanh et al., 2016; Begna, 2020; Belay et al., 2020; Sultan & Raina, 2020; Casals et al., 2023). Nevertheless, it is also known that some garlic varieties have phenotypic plasticity in response to different environments (Volk & Stern, 2009; Kizil & Khawar, 2017; Sánchez-Virosta et al., 2021). Some studies have revealed that different agronomic responses exist in garlic varieties under various environmental factors e.g., photoperiod and temperature (Atif et al., 2019; Mathew et al., 2011), water stress (Sánchez-Virosta & Sánchez-Gómez, 2019), different fertilizer levels (Shree et al., 2014), climatic changes (Tchórzewska et al., 2017; Mahmudah et al., 2021), and planting time (Alsup-Egbers et al., 2020).

Lumbu Hijau, Lumbu Kuning, Tawangmangu Baru, and Sangga Sembalun are garlic varieties commonly planted in Indonesia. Agronomic characteristics of these varieties have been studied previously whether relating to fertilizer level and modification in field practices (Basuki et al., 2019; Rahayu et al., 2020) or both genotypic and cultivation technique combination (Aswani et al., 2022). Although evaluations of those varieties have been done in many locations such as highlands of Malang (Anjani et al., 2019), Bromo (Saidah et al., 2022), Cianjur (Dianawati et al., 2022), Sembalun (Hadiawati et al., 2022), Lembang (Muliani et al., 2023), Dieng (Azmi et al., 2022), Alahan Panjang (Kristina et al., 2023) or lowlands of Muaro Jambi (Kurniaty et al., 2022), however, genetic stability evaluation is rarely reported. Genetic stability is an important factor in breeding evaluations as well as in developing recommendations for farmers in different locations (Obel et al., 2020; Gomes et al., 2019). The study aimed to evaluate agronomic responses of four garlic varieties planted on two different uplands in West Java.

MATERIALS AND METHODS

Research site

The research was carried out from April to December 2021. Cloves from four garlic genotypes (G) were planted in two locations (L) Margahayu Field Station, Lembang, West Bandung Regency with an altitude of 1,250 m above sea level (6°48'06.4"S 107°38'56.1"E) and Panundaan Village, Ciwidey, Bandung Regency with the altitude of 1,200 m above sea level (7°06'52.1"S 107°26'21.2"E). Both sites are located in the West Java Province, Indonesia.

Climatology data were collected from Margahayu station at Lembang and Bandung station the nearest meteorological station from Ciwidey. Soil samples from Lembang and Ciwidey were taken by surface sampling from five points at each location. Samples were analyzed at the Integrated Laboratory of Indonesian Vegetable Research Institute (IVEGRI), Lembang. Climatic and edaphic data were respectively presented in Figure 1 and Table 1.

Research design

Genotype (variety) and location were plotted into a randomized complete block design with each experimental unit consisting of three replications. Vegetative seeds were from four Indonesian released garlic varieties, i.e., Lumbu Putih, Lumbu Hijau, Lumbu Kuning, and Tawangmangu Baru. These seed bulbs were produced through the nucleus seed project in 2020 which selected and purified the population of each tested variety. Therefore these seed bulbs had passed their dormancy phase when this experiment was started in 2021. Bulbs were processed for separating individual cloves to be planted in a single planting hole.

Table 1. Soil characteristics of study sites.

Parameter	Location	
	Lembang	Ciwidey
Texture (sand:silt:clay (%))	Silty Loam (34:63:3)	Loam (35:41:24)
pH (H_2O)	6.1	6.8
Organic matter (%)	5.51 (very high)	2.32 (medium)
N (%)	0.63 (high))	0.33 (medium)
C/N ratio	9 (low)	7 (low)
Available P_2O_5 Olsen (ppm P)	149.7 (very high)	1,392.6 (very high)
Total P_2O_5 HCl 25% (mg/100g)	380.65 (very high)	1,281.52 (very high)
Total K_2O HCl 25% (mg/100g)	28.38 (medium)	60.59 (very high)
Al dd cmol (+)/kg	0.27 (very low)	0.00 (very low)
H dd cmol (+)/kg	0.07 (very low)	0.10 (very low)
Ca cmol (+)/kg	4.62 (very low)	20.34 (very low)
Mg cmol (+)/kg	1.28 (very low)	3.15 (very low)
K cmol (+)/kg	0.52 (very low)	1.82 (very low)
Na cmol (+)/kg	0.09 (very low)	0.22 (low)
Cation Exchange Capacity (cmol (+)/kg)	25.56 (high)	23.17 (medium)
Base saturation (%)	25 (high)	110 (very high)

The cultivation procedure adopted the Innovative Technology for Garlic Cultivation (TIBBP) (Basuki et al., 2019). For initial preparation, the raised bed was shaped: 100 cm (width) x 30 cm (height) and 50 cm as spacing between beds.

Dolomite was spread and distributed on top of the bed using a recommendation level of 2 tons ha^{-1} followed by the applications of organic manure (chicken manure) 15 tons ha^{-1}) and phosphate fertilizer (SP36) 375 kg ha^{-1}. Each soil bed was covered with organic mulch (rice straw) immediately after planting. The planting space was 12.5 cm x 12.5 cm.

Nitrogen (ZA, 286 kg ha^{-1}) and potassium (KCl, 50 kg ha^{-1}) fertilizers were applied on the 21st, 35th, 49th, and 63rd days after planting (DAP). Plant watering in Lembang station was conducted with manual irrigation using a water hose. Meanwhile, plant watering in Ciwidey was conducted with a traditional method using a basin irrigation system.

Observation on vegetative and yield characters

Growth and yield data were obtained from 15 plants that were randomly selected . Plant height, number of leaves, pseudo-stem diameter, chlorophyll content (SPAD value) and number of stomata were measured at 90 DAP. A portable chlorophyll meter (SPAD-502, Minolta) was used to perform readings of leaf chlorophyll. The number of stomata was observed and counted using ZEISS Microscope™ with a 10x magnification.

The yield components including the weight of fresh bulbs, diameter, and height of fresh bulbs were observed immediately after harvest time (100-120 DAP). The fresh bulbs were then sun-dried in a screen house for 1-2 weeks. The percentage of weight loss, weight, height, and diameter of dry bulbs were evaluated after the harvest was kept for three months in the storehouse.

Statistical analysis

Analysis of variance and the following Tukey's post hoc test ($p<0.05$) were computed using statistical software of PKBT-STAT version 3.1 (www.pbstat.com). Pearson's correlation between characters was analyzed by using IRRI's Statistical Tool for Agriculture Research (STAR) (Azrai et al., 2017).

RESULTS AND DISCUSSION

Soil and climatic conditions

The soil texture of Lembang was dusty silty loam (34% sand, 63% silt, and 3% clay) while Ciwidey was loam (35% sand, 41% silt, and 24% clay) (Table 1). Soil in Lembang had slightly acidic soil and had very high organic matter (5.51%) compared to Ciwidey which had neutral soil with medium organic matter (2.32%). The nitrogen content of Lembang was higher (0.63%) than Ciwidey (0.33%). The base saturation of Lembang and Ciwidey soils are categorized as high and very high, respectively.

Lembang had a lower minimum temperature (15.98 °C) and maximum temperature (24.97 °C) compared to Ciwidey (20.14 °C and 29.35 °C, respectively) (Figure 1). Lembang also received much lower rainfall (165.46 mm per month) compared to Ciwidey (278.27 mm per month). Both Lembang and Ciwidey also have a fluctuating relative humidity with the biggest difference in RH between these locations occurring at 90 DAP.

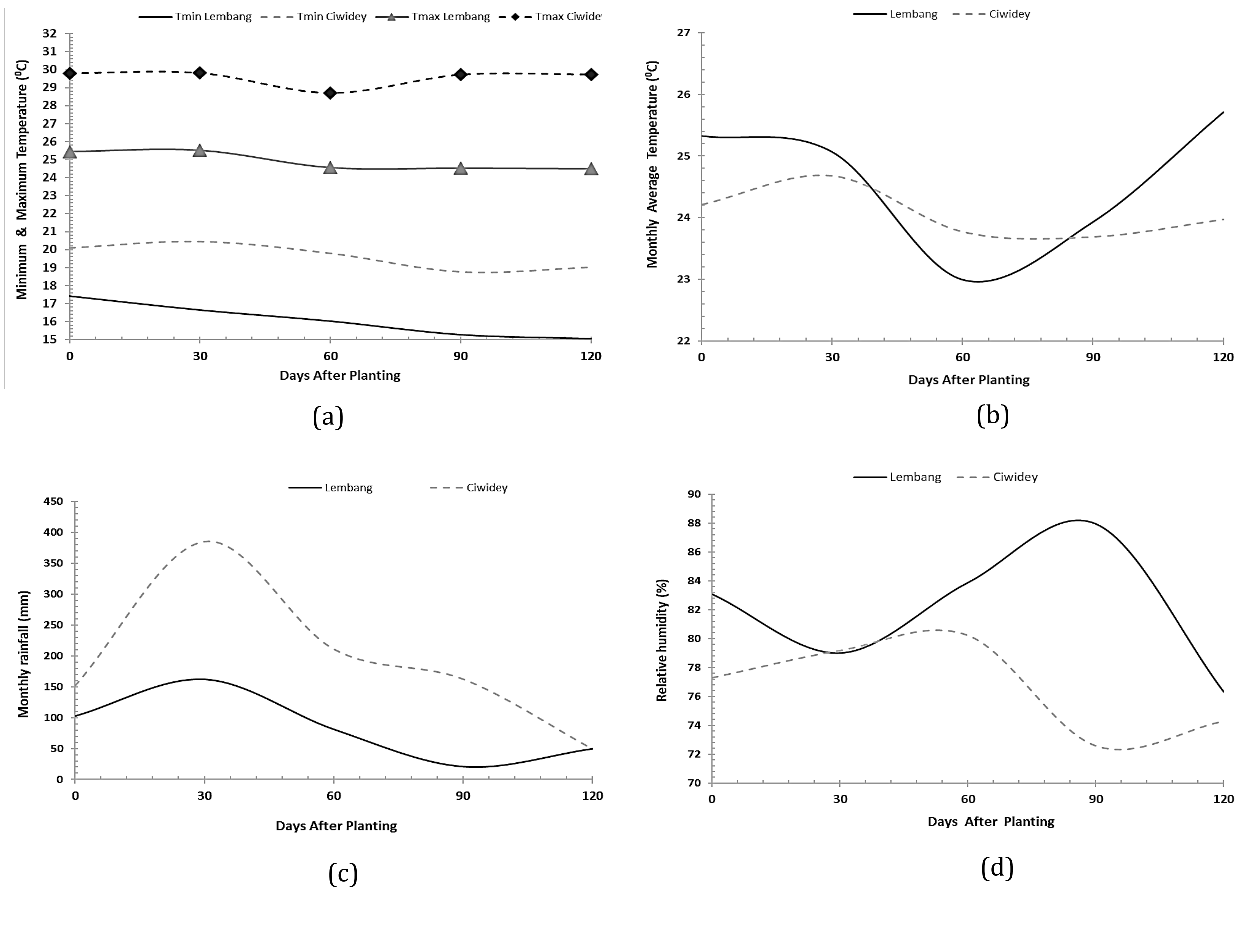

Figure 1. Climate conditions at two experimental sites during garlic production (May-September 2021): (a) Maximum and minimum temperature, (b) Monthly average temperature, (c) Monthly rainfall, and (d) Relative humidity (Rh).

Analysis of variance

Our study showed that G×L interaction resulted in highly significant differences ($p<0.01$) in plant height, pseudo-stem diameter, and diameter of the dry bulb as well as significant differences ($p<0.05$) in the number of stomata, the weight of the fresh bulb, and diameter of the fresh bulb (Table 2). Furthermore, different planting locations significantly affected the number of leaves, the height of the fresh bulb, and the percentage of weight loss regardless of genotype. On the other hand, genotypic differences significantly affected the number of leaves dan chlorophyll content regardless of location.

Table 2. Summary of ANOVA of four garlic genotypes grown in two locations.

Variables	Genotype (G)	Location (L)	G × L interaction	CV (%)
Plant height	*	**	**	4.63
Number of leaves	*	*	ns	5.78
Pseudo-stem diameter	**	**	**	4.08
Chlorophyll content (SPAD value)	*	ns	ns	4.38
Number of stomata	ns	**	*	11.65
Fresh bulb				
Weight	*	**	*	14.34
Diameter	ns	ns	*	10.06
Height	ns	*	ns	9.30
Dry bulb				
Weight	*	**	*	13.01
Diameter	*	ns	**	5.67
Height	ns	ns	ns	9.64
Percentage of weight loss	ns	*	ns	18.93

Note: * significant at α = 5%, ** significant at α = 1%, ns = not significant

The G×L interaction was highly significant in plant height and pseudo-stem diameter. Lumbu Hijau performed the tallest plants when planted in Ciwidey (60.25 cm) yet performed the shortest plants in Lembang (58.72 cm) (Table 3). Lumbu Putih had the tallest plants when planted in Lembang (68.53 cm) but it performed the shortest plants in Ciwidey (52.73 cm). Unlike our study, a previous experiment on the highland of Cianjur found that Lumbu Kuning had the tallest plants while Lumbu Putih had the shortest plants (Dianawati et al., 2022). Another study on the highland of Sembalun showed that Tawangmangu Baru had the tallest plants while Lumbu Putih had the shortest plants (Hadiawati et al., 2022). The biggest pseudo-stem diameter was observed from Tawangmangu Baru planted in Lembang (11.07 mm) whereas the smallest was observed from Lumbu Putih planted in Ciwidey (7.93 mm). On average, all varieties had higher pseudo-stem diameter in Lembang ($p<0.05$) compared to when they were planted in Ciwidey. On the highland of Sembalun of Lombok Island, Tawangmangu Baru genotype also had the tallest plants while Lumbu Hijau had the shortest plants (Hadiawati et al., 2022).

Table 3. Plant height and pseudo-stem diameter of garlic genotypes grown in Lembang and Ciwidey.

Genotype	Plant height (cm)			Pseudo-stem diameter (mm)		
	Lembang	Ciwidey	Mean	Lembang	Ciwidey	Mean
Tawangmangu Baru	66.95a	59.53a	63.24a	11.07a	8.30a	9.68a
Lumbu Hijau	58.72b	60.25a	59.48ab	9.23b	8.37a	8.80b
Lumbu Kuning	59.30b	54.65ab	56.98b	9.52b	8.47a	9.00b
Lumbu Putih	68.53a	52.73b	60.63ab	10.70a	7.93a	9.32ab
HSD 5%	6.79	6.79	4.80	0.91	0.91	0.65
Means	63.38a	56.79b	-	10.13a	8.27b	-

Note: Numbers followed by the same letter in the same column are not significantly different based on Tukey's HSD test with a level of significance of 5%

The highly significant differences in plant height and pseudo-stem diameter among locations were presumably caused by the effect of G×L interaction; as it was depicted from the steep declines between Lembang and Ciwidey (Figure 2a-b). It suggested that the plant height and pseudo-stem diameter were highly responsive to environments in our study. Lembang supported more vigorous (taller plants, bigger pseudo-stem) garlic plants which might relate to soil characteristics such as silty loam texture that is more porous for root growth. Soil texture determines soil fertility considering its ability for providing nutrients, regulating water, air movement, and soil compactness (Phogat et al., 2015).

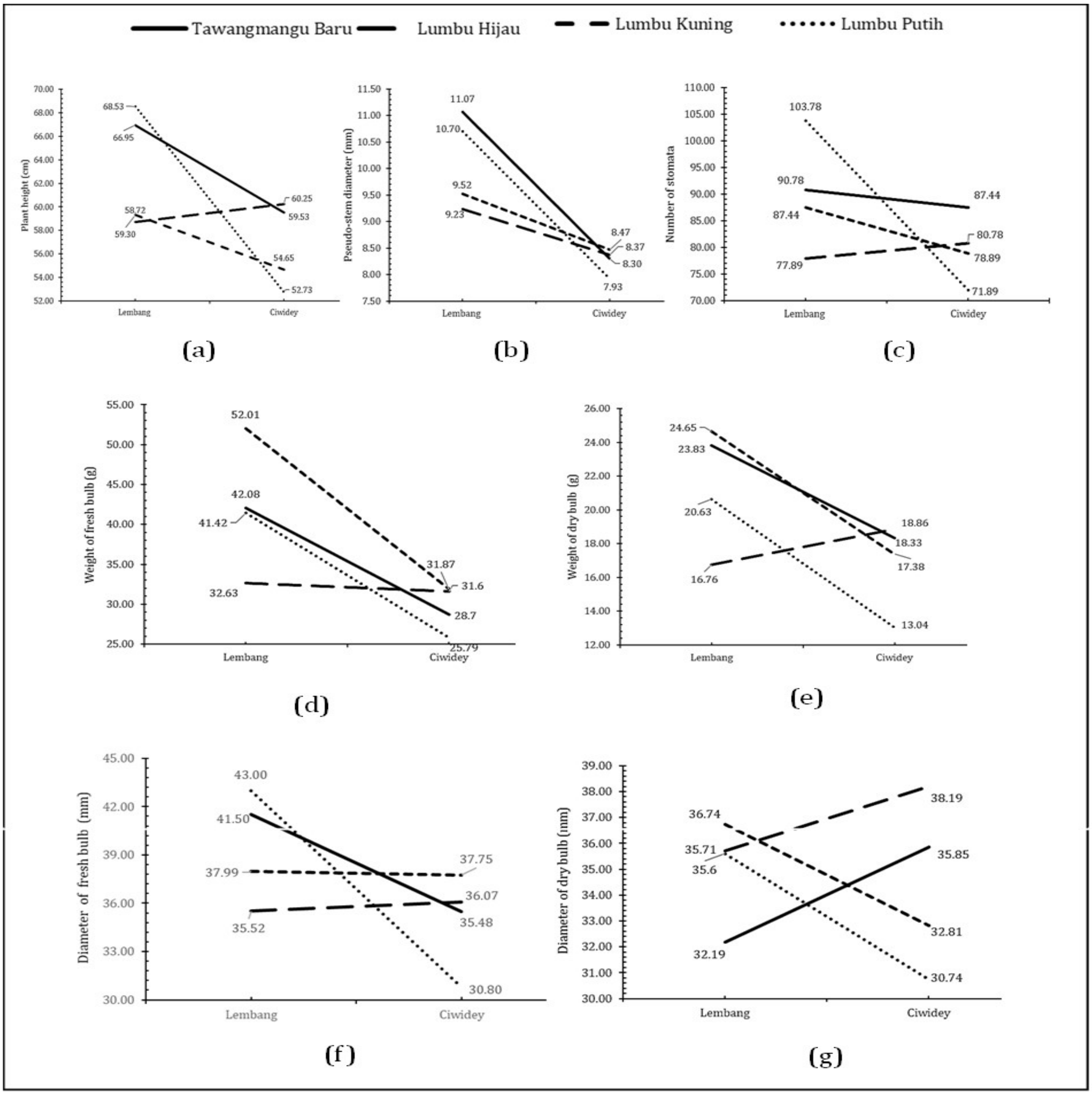

Figure 2. G×L interaction on (a) plant height; (b) pseudo-stem diameter; (c) number of stomata; (d) weight of fresh bulb; weight of dry bulb; (f) diameter of the fresh bulb; and (g) diameter of the dry bulb

The location also affected the number of stomata significantly. The highest number of stomata (103.78) was observed from Lumbu Putih planted in Lembang (Table 4). Interestingly, the same variety had the lowest number of stomata when planted in Ciwidey (71.89). Except for Lumbu Hijau, all varieties had a lower number of stomata when planted in Ciwidey where Lumbu Putih had the steepest decline (Figure 2c). This result was probably due to the different humidities in both locations when the number of stomata was observed in July 2021 (90 Days After Planting). Lembang had increased humidity (83.45-85.45%) and received lower rainfall whereas Ciwidey experienced decreasing humidity (72.94-73.23%) yet received higher rainfall (Figure 1). Higher air humidity with considerable dry soil can trigger stomata opening (Driesen et al., 2020). Previous studies also revealed that stomatal characters were species-specific (Zhang et al., 2012) and affected by both genetic and environmental changes such as light and CO_2 concentration in the atmosphere (Hunt et al., 2021) or land type (Sun et al., 2021).

Table 4. Number of leaves, chlorophyll content (SPAD value) and number of stomata of garlic genotypes grown in Lembang and Ciwidey.

Genotype	Number of leaves			Chlorophyll content (SPAD value)			Number of stomata		
	Lembang	Ciwidey	Mean	Lembang	Ciwidey	Mean	Lembang	Ciwidey	Mean
Tawangmangu Baru	9.45	9.46	9.45a	67.26	64.58	65.92ab	90.78ab	87.44a	89.11
Lumbu Hijau	8.70	8.03	8.36b	62.85	65.16	64.01b	77.89b	80.78a	79.33
Lumbu Kuning	9.28	8.48	8.88ab	65.76	67.03	66.40ab	87.44ab	78.89a	83.17
Lumbu Putih	9.32	8.37	8.84ab	68.93	70.24	69.58a	103.78a	71.89a	87.84
HSD 5%	-	-	0.89	-	-	5.02	24.11	24.11	-
Mean	9.19a	8.58b		66.20	66.75		89.97a	79.75b	

Note: Numbers followed by the same letter in the same column are not significantly different based on Tukey's HSD test with a level of significance of 5%

Analysis of variance showed that the number of leaves was significantly affected by independent G×L interaction , while chlorophyll content (SPAD value) was significantly affected only by genotypic factors regardless of location (Table 4). The average number of leaves of genotypes in Lembang was higher than in Ciwidey ($p<0.05$). Among tested varieties, Tawangmangu Baru had the highest number of leaves (9-10 leaves per plant) whereas Lumbu Hijau had the smallest number of leaves (8 leaves per plant). Significant differences between genotypes were found in chlorophyll content (SPAD value). The highest mean of chlorophyll content was observed from Lumbu Putih (69.58) whereas the lowest mean was observed from Lumbu Hijau (64.01). These results confirmed previous works suggesting that the number of leaves (El Nagar & El-Zohiri, 2015; Robledo-Paz & Manuel, 2012) and chlorophyll content in SPAD value (Ghoshi et al., 2020; Aswani et al., 2022; Kendarini et al., 2022) were significantly influenced by genotype.

The effect of G× L interaction on yield characters

Significant G×L interaction were found on both weights of fresh bulb and the weight of dry bulb (Table 2). All tested varieties except Lumbu Hijau produced higher yields in Lembang (Table 5). The highest fresh and dry bulb weights were observed from Lumbu Kuning which was grown in Lembang (52.01 g and 24.65 g, respectively) whereas the lowest fresh and dry bulb weights were observed from Lumbu Putih in Ciwidey (25.79 g and 13.04 g, respectively). The average weight of fresh and dry bulbs in Lembang was also higher than those in Ciwidey. All tested varieties showed declining graphic lines for the weight of fresh and dry bulb (Figure 2d-e). This significant difference in the weight of fresh bulb is possibly due to the different amounts of rainfall in both locations (Figure 1). During garlic's growing period in our research from April to September 2021, Lembang received a lower amount of annual rainfall than Ciwidey. Minimum and maximum temperatures in Lembang were also lower than in Ciwidey (Figure 1). Garlic requires lower precipitation but with enough irrigation and slightly warm temperature for its optimal bulb formation (Kamenetsky, 2007; Wu et al., 2016).

Table 5. Bulb weight and diameter of garlic genotypes grown in Lembang and Ciwidey.

Genotype	Fresh bulb weight (g)			Dry bulb weight (g)			Dry bulb diameter (mm)			Fresh bulb diameter (mm)		
	L	C	Mean	L	C	Mean	L	C	Mean	L	C	Mean
Tw.Baru	42.08ab	28.70a	35.39ab	23.83a	18.33a	21.08a	32.19a	35.85ab	34.02ab	41.50a	35.48a	41.50a
L. Hijau	32.63b	31.60a	32.12b	16.76b	18.86a	17.81a	35.71a	38.19a	36.95a	35.52a	36.07a	35.52a
L. Kuning	52.01a	31.87a	41.94a	24.65a	17.38a	21.02a	36.74a	32.81bc	34.78ab	37.99a	37.75a	37.99a
L. Putih	41.42ab	25.79a	33.61ab	20.63ab	13.04a	16.84a	35.60a	30.74c	33.17b	43.00a	30.80a	43.00a
HSD 5%	12.51	12.51	8.84	6.09	6.09	4.30	4.80	4.80	3.40	9.15	9.15	9.15
Means	42.04a	29.49b	-	21.47a	16.90b	-	35.06	34.40	-	39.50	35.02	39.50

Note: Numbers followed by the same letter in the same column are not significantly different based on Tukey's HSD test with a level of significance of 5%; L: Lembang, C: Ciwidey

The diameters of fresh bulb from four tested varieties were only affected significantly by location (Table 5). For example, when planted in Lembang, Tawangmangu Baru had a larger diameter (41.5 mm) of its fresh bulb compared to when planted in Ciwidey (35.48 mm). From Lembang to Ciwidey, Lumbu Putih and Tawangmangu Baru showed steeper declines while Lumbu Kuning and Lumbu Hijau had flatter lines (Figure 2f). However, significant differences in the diameter of dry bulb were observed from the interaction between genotype and location. Lumbu Hijau planted in Ciwidey produced the biggest diameter of dry bulbs (38.19 mm), while the smallest diameter of dry bulbs was observed from Lumbu Putih in the same location (Table 5). It showed that while Lumbu Kuning and Lumbu Putih had increasing diameters of dry bulb in Lembang, Tawangmangu Baru and Lumbu Hijau had decreasing values, and vice versa. These results supported the previous study on the highland of East Java that found the effect of G×L interaction on garlic bulb diameter (Gomes et al., 2019).

Although both locations were treated with the same fertilizer dose and cultivation technique, they have different soil properties (Table 1). Silty loam soil of Lembang served improved root penetration increasing nitrogen uptake which lead to more nitrogen accumulation in bulbs. This result also is in agreement with previous work by Ade-Ademilua & Utibe (2017) denoting that garlic produced bigger bulbs in silty loam soil. Lembang and Ciwidey soils have respective pHs of 6.1 and 6.8 which are suitable for garlic growth (Basuki et al., 2019). Many studies showed that the cation exchange capacity (CEC) is an indicator of soil fertility since it depends on organic matter and clay content in soil (AbdelRahman et al., 2022; Bedolla-Rivera et al., 2020; Hailu et al., 2015; Kong et al., 2021; Xiao et al., 2021). The CEC value in Lembang soil was 25.56 (high) higher than in Ciwidey soil with 23.17 (medium), that presumably, garlic grown in Lembang received more nutrients than in Ciwidey soil. Soil with a high base saturation indicates a base/cation content which is generally a high plant nutrient and is a sign that it has not been leached a lot (Ng et al., 2022). The C/N ratio of Lembang and Ciwidey soils is categorized as low, a low C/N indicates good organic matter decomposition (Nivethadevi et al., 2021). However, nutrient absorption in plants was not evaluated. It is interesting in the future to evaluate nutrient absorption in garlic from different locations.

Correlation between agronomic characters

Pearson's correlation of plant height in Lembang was highly correlated ($r>0.50$) to all vegetative traits (number of leaves, pseudo-stem diameter, chlorophyll content in SPAD value, and number of stomata) and one yield character i.e., the diameter of fresh bulb (Table 6). It indicated that taller plants tend to have a larger diameter of pseudo-stem and fresh bulb when grown in Lembang. This is possibly due to their larger photosynthetic area which results in higher assimilate production (Santos et al., 2022). The correlation between the number of stomata and fresh bulb diameter in Lembang was also high ($r=0.73$). Stomata have an important role in transpiration and photosynthesis (Lawson & Blatt, 2014).

Table 6. Pearson's correlation between traits of four garlic genotypes grown in two locations.

Lembang	PH	NL	PD	CHC	NST	WFB	DFB	FBH	WDB	PWL	DDB
NL	0.54	-									
PD	0.86	0.64	-								
CHC	0.57	0.75	0.56	-							
NST	0.66	0.60	0.45	0.86	-						
WFB	-0.03	0.58	0.19	0.36	0.16	-					
DFB	0.60	0.39	0.40	0.67	0.73	0.08	-				
HFB	0.42	0.15	0.05	0.28	0.55	-0.36	0.21	-			
WDB	0.15	0.68	0.28	0.39	0.20	0.64	0.04	-0.02	-		
PWL	-0.17	-0.07	-0.11	0.01	0.04	0.38	0.13	-0.31	-0.46	-	
DDB	-0.38	-0.39	-0.38	-0.41	-0.17	0.17	-0.40	-0.21	-0.32	0.56	-
HDB	-0.35	0.00	-0.61	0.01	0.10	0.05	0.00	0.33	0.28	-0.23	-0.14
Ciwidey											
NL	0.03	-									
PD	0.65	-0.27	-								
CHC	-0.37	-0.12	-0.02	-							
NST	0.56	0.59	0.19	-0.44	-						
WFB	0.59	-0.44	0.91	0.11	0.00	-					
DFB	0.62	-0.16	0.81	-0.21	0.40	0.79	-				
HFB	0.71	-0.40	0.75	-0.13	0.28	0.69	0.79	-			
WDB	0.82	-0.07	0.84	-0.28	0.39	0.79	0.85	0.78	-		
PWL	-0.16	-0.71	0.32	0.62	-0.60	0.51	0.09	0.14	-0.10	-	
DDB	0.60	0.15	0.09	-0.71	0.67	0.03	0.28	0.35	0.45	-0.62	-
HDB	-0.13	-0.49	0.47	0.28	-0.41	0.54	0.44	0.35	0.28	0.49	-0.45

Note: PH- plant height; NL- number of leaves; PD- pseudo-stem diameter; CHC- chlorophyll content (SPAD value); NST- number of stomata; WFB- weight of fresh bulb; DFB- diameter of fresh bulb; HFB- height of fresh bulb; WDB- weight of dry bulb; PWL- percentage of weight loss; DDB- diameter of dry bulb; HDB- height of dry bulb.

However, in Ciwidey, plant height was highly correlated (r>0.50) only with two vegetative characters, i.e., pseudo-stem diameter and the number of stomata, yet it correlated with most of the yield characters i.e., the weight of fresh bulb, diameter of fresh bulb, height of fresh bulb, weight of dry bulb and diameter of dry bulb (Table 6). Pseudo-stem diameter also had high positive correlations (r>0.70) with the weight of fresh bulb, the diameter of fresh bulb, the height of fresh bulb, and the weight of dry bulb. This varying results of correlation might regard to different agroclimate of each location since phenotype is resulted from genetic and environment interaction. However our study supported previous studies that found that plant height and pseudo-stem diameter had positive correlations with bulb yield components (Panthee et al., 2006; Batth et al., 2013; Sable et al., 2020; Santos et al., 2022).

CONCLUSION

Agronomic performance of garlic varieties in Lembang was better than in Ciwidey. Lumbu Hijau had higher plant height, weight, and diameter of dry bulb when planted in Ciwidey. Positive correlations between plant height, pseudo-stem diameter and bulb (yield) were found in both locations. Agronomic performances of garlic were resulted from the genotype and environment interaction, indicating the strong effect of the environment on yield.

ACKNOWLEDGEMENT

We thank IVEGRI, IAARD, Ministry of Agriculture for the research facilities. We also thank the anonymous reviewers for their helpful corrections on this article.

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