EFFECTS OF PLANT SPACING AND THE NUMBER OF CLOVES PER PLANTING HOLE ON PURPLE BLOTCH DISEASE, GROWTH AND YIELD OF GARLIC

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Abstract. Field experiment at Indonesian Vegetable Crops Research Institute, Lembang, West Java, Indonesia was conducted to examine the effect of plant spacing and the number of cloves per planting hole on purple blotch disease (*Alternaria porri*), growth, and yield of garlic. The garlic cultivar used was an Indonesian local cultivar, Lumbu hijau. The first experiment was arranged as split plot in a randomized complete block design with three replications. The main plots were plant spacing with six levels (10x5 cm, 10x10 cm, 10x15 cm, 10x20 cm, 15x20 cm, and 20x20 cm) and the sub plots were the numbers of garlic cloves per planting hole with four levels (1, 2, 3 or 4 cloves). The second experiment was conducted to examine the growth and yield of garlic planted with optimal combination of spacing and the number of seed clove (10x15 cm plant spacing with two cloves), compared to the common practice (10x15 cm plant spacing with one clove per hole). The results of the first experiment showed that plant spacing and the number of clove per planting hole examined did not significantly affect the development of purple disease in garlic. The garlic growth was influenced by the number of clove per hole rather than plant spacing. In both experiments, combination plant spacing of 10x15 cm with two cloves per planting hole increased the garlic yield per unit area 2.3-3.2 folds compared to farmer’s common practice. This study showed that appropriate combination between plant spacing and the numbers of cloves per planting holes can increase the garlic productivity.
Keywords: *Alternaria porii, garlic productivity, Indonesia, Lumbu hijau, plant density*

Introduction

Garlic (*Allium sativum* L.) is the most important horticultural crops in Indonesia due to its daily use as the main spice of almost all Indonesian cuisines. In addition, garlic can also be used for medicinal purposes. However, more than 90% of national demand has still been supplied by imported garlic. To reduce its dependency on the import, Indonesian government has supported domestic garlic production (Rafani et al., 2022) and has tried to increase garlic productivity and quality (Sandrakirana et al., 2018). Efforts to increase the productivity of garlic include the selection of varieties, expansion of land area and improvement of cultivation techniques (Sandrakirana et al., 2018). One of the techniques in crop cultivation that can improve plant productivity is the management of plant density.

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In garlic cultivation, plant density can be managed through arrangement of plant spacing and the number of clove seed per planting holes.

Plant spacing can affect plant growth and the yield. The narrow plant spacing may lead to competition in obtaining resources such as water, nutrients and light. In wide plant spacing, the growth of the plant may be more optimal. However, it may be not efficient in using the space and therefore the yield per unit area is not maximal (Postma et al., 2020). Plant spacing affects light interception and the ability of plant to carry out photosynthesis that is important for supporting growth and the production of garlic bulb. The optimum density of garlic plants for photosynthesis was 600,000-750,000 plants/ha (Moravćević et al., 2011). Optimum garlic plant density can be varied, depending on the plant variety and the soil condition (Fakhar et al., 2019).

Plant density can also affect the development of plant disease. Purple blotch disease caused by *Alternaria porri* is the most destructive disease in *Allium* spp., which may cause up to 90% yield loss (Dar et al., 2020). Purple blotch disease also becomes the most prevalent disease of garlic in Indonesia (Krestini et al., 2018). The disease is usually started on older leaves as brownies-purple necrotic lesions which can enlarge so that the leaves become dried. The disease inhibits bulb formation and maturation (Dar et al., 2020) and the pathogen can also infect the bulb (Sandrakirana et al., 2018). The development of purple blotch disease is favoured by high humidity (80-90%) and moderate temperature (25-30^{o}C). In favourable environmental condition, the pathogen sporulates on infected leaves and the conidia are spread mostly by water splash and wind. The pathogen overwinters mostly on plant debris (Dar et al., 2020). The most common control measure of the disease was the use of pesticide. However, to reduce the negative impacts of excessive use of pesticides, integrated control measures including cultural techniques such as the arrangement of plant spacing need to be implemented.

Plant spacing can affect plant disease development, and therefore appropriate plant spacing can inhibit the disease progress. Mengesha and Tesfaye (2015) reported that garlic with wider intra row plant spacing (20 cm) had lower incidence and severity of the rust disease (*Puccinia allii*), compared to narrower spacing (10 cm). Ahmed et al. (2017) also reported the same trend in which the wider intra row plant spacing (20 cm) led to lower rust disease severity in garlic than the narrower plant spacing (10 cm).

In addition to plant spacing, plant density is also depended on the number of seed per planting hole. Since garlic bulb has several cloves inside, the plant density of garlic depends on its plant spacing and the numbers of seed cloves per planting hole. Farmer usually plant one seed clove per planting hole. Increasing the number of seeds per planting hole can result in higher population and yield per unit area. Sorghum with 3-4 seeds per planting hole increased the yield by 30.0%-50.5% compared to one seed (Pithaloka et al., 2015). Planting two or three shallot bulbs per holes could also increase the shallot yield per unit area (Sufyati et al., 2006).

In Indonesia, garlic was commonly planted with 10x15 cm plant spacing and one clove per planting hole (Sandrakirana et al., 2018). The increase in plant population by combination between plant spacing and the number of garlic clove seed per planting hole has not been studied yet. Therefore, the objective of this study was to evaluate the interaction between plant spacing and the number of cloves per hole on the growth, yield and the development of purple blotch disease of garlic.

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Methods

First experiment

The experiment was conducted at experimental field of Indonesian Vegetable Crops Research Institute (IVEGRI), Lembang, West Bandung, West Java, Indonesia. This site is 1,250 m above sea level and located at 6° 48' 07.8" S and 107°38' 57.1" E with Andisol soil type. The experiment was conducted from December 2020 to April 2021. The temperature conditions at that time were 17.6-24.9^{o}C, humidity 87.46% with an average rainfall of 7.8 mm.

The field experiment was laid out as split plot in a randomized complete block design with three replicates. The main plots were plant spacing with six levels, which were 10x5 cm, 10x10 cm, 10x15 cm, 10x20 cm, 15x20 cm, and 20x20 cm. The sub plots were the numbers of garlic cloves per planting holes with four levels, which were 1, 2, 3, and 4 cloves per planting hole. These combinations resulted in plant population of garlic as in *Table 1*.

Table 1. *Plant populations in each combination treatments*

Plant spacing (cm)	*Number of cloves*			
	1	2	3	4
10X5	1.024,000	2,048,000	3,072,000	4,096,000
10X10	512,000	1,024,000	1,536,000	2,048,000
10X15	384,000	768,000	1,152,000	1,536,000
10X20	256,000	512,000	768,000	1,024,000
15X20	288,000	576,000	864,000	1,152,000
20X20	160,000	320,000	480,000	640,000

Garlic variety used in the study was Indonesian local variety, *Lumbu hijau*, which is commonly cultivated by the farmers. The garlic seed bulbs were obtained from IVEGRI. The garlic cloves with relatively uniform size were selected and used as planting materials. The plot size of each combination treatment was 2 m x 1 m covered by silver plastic mulch. Distance between the plots was 1 m, while between blocks was 1.5 m. The plots were watered two days before planting and thereafter irrigation was done as needed. Fertilizers were applied based on common recommendations for garlic cultivation. Basic fertilizers were applied before planting in the form of organic fertilizer (chicken manure) at a dose of 10 tons/ha and SP 36 300-500 kg/ha. After planting, supplementary fertilizers were applied three times, which were at 15 days after planting (DAP) (urea 200 kg/ha and NPK 100 kg/ha), at 35 DAP (urea 100 kg/ha and NPK 200 kg/ha) and at 50-55 DAP (NPK 300 kg/ha) (Sandrakirana et al., 2018).

The variables of garlic growth observed were root length, leaf length, pseudo-stem height, leaf area, and plant biomass. These variables were observed at 10 weeks after planting (WAP) by taking 10 sample plants randomly from each plot. The purple blotch disease intensity was observed every week started from the first appearance of symptoms of the disease (which was at 4 WAP) until two weeks before harvest. The intensity of the disease was calculated using the following formula:

$$DI = \frac{\sum nxv}{NxZ} x100\% \quad \text{(Eq.1)}$$

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where, DI is Disease intensity; n is the number of leaves with the same score; v is the particular score; N is number of leave observed (per plant); and Z is highest disease score used. The scoring used was 0: No symptoms; 1: $0 \leq x \leq 12\%$ leaf area infected; 2: $12\% \leq x \leq 25\%$ leaf area infected; 3: $25\% \leq x \leq 50\%$ leaf area infected; 4: $50\% \leq x \leq 75\%$ leaf area infected; 5: $75\% \leq x \leq 100\%$ leaf area infected. The data were used to calculate the Area Under Disease Progress Curve (AUDPC) (Campbell and Madden, 1990).

$$AUDPC = \sum_{i}^{n-1} \left(\frac{y_i + y_{i+1}}{2}\right) (t_{i+1} - t_i) \quad \text{(Eq.2)}$$

In which Y_{i+1} is observation data in i+1; Yi is observation data in i; t_{i+1} is observation time in i+1; ti is observation time in i.

Data were analysed statistically with Analysis of variance using SPSS software version 24.00. Homogeneity of the data were checked and transformed if it was needed. The significant differences among treatments were tested using Tukey's HSD test at significant level of 0.05 ($p < 0.05$).

Second experiment

This second experiment was conducted to confirm the effect of plant spacing and the number of cloves on the growth and yield of garlic. The experiment was conducted from April to August 2022. The environmental condition during the experiment was the temperature range between 15.9-24.5°C, 86.63% humidity, and average rainfall amount 5.35 mm. The plant spacing and numbers of clove tested were the optimal combination (10x15 cm with two cloves per planting hole) and the farmer's common practice (10x15 cm plant spacing with one clove per planting hole). The experiment was arranged in randomized complete block design with 20 replications. The size of each plot was 2x1 m and the cultivation methods were similar to the first experiment. As the experiment was focused on the effects of the treatments on the garlic yield, so the pests and diseases were controlled by application of pesticides.

The variables observed were the height of pseudostem and the numbers of leaves, which were observed at 4 and 11 weeks after planting by taking five sample plants randomly from each plot. The yield variables observed were the bulb diameter, numbers of cloves per bulb, the bulb weight per plant, and the bulb weight per plot. Data were analysed statistically using SPSS software version 24.00. The difference among treatments was tested using t test at significant level of 0.05 ($p < 0.05$).

Results and Discussion

Effect of plant spacing and number of cloves per planting hole on garlic growth

Plant spacing and the number of garlic seed clove per planting hole determine plant population. In this study, the statistical analysis showed that there was no significant effect of interaction between plant spacing and the numbers of garlic cloves per planting holes on all growth variables observed. Plant spacing tested did not significantly influence garlic growth. However, root length, pseudo stem height, leaf length, and shoot fresh weight of garlic were significantly influenced by the number of cloves per planting hole (*Table 2*).

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Table 2. *The results of variance analysis in various plant growth variables*

Source	Degree of freedom	Significance values					
		Root length	Pseudostem height	Leaf length	Leaf area	Biomass weight per plant	AUDPC
Replication	2	0.174	0.039	0.901	0.758	0.030	0.020
Spacing	5	0.188	0.116	0.079	0.177	0.182	0.217
Main plot error	10						
Numbers of cloves	3	0.000**	0.000**	0.000**	0.906	0.000**	0.183
Spacing x cloves	15	0.921	0.131	0.742	0.414	0.308	0.504
Sub plot error	36						
Total	71						

The increase in the numbers of cloves planted per hole led to an increase in pseudostem height, leaf length and root length (*Table 3*). Nutrition and water competition tend to accelerate the root elongation to obtain the nutrients (Li et al., 2017; White, 2019). Li et al. (2017) also reported that the denser plant population, the longer the root length.

Table 3. *The effect of plant spacing and number of cloves per planting hole on the agronomic variables of garlic*

	Root length (mm)	Pseudostem height (mm)	Leaf length (cm)	Leaf area (mm)	Biomass weight per plant (g)
Plant spacing (cm)					
10X5	27.5 ± 6.21 a	39.6 ± 5.91 a	32.1 ± 5.91 a	49.1 ± 12.68 a	15.1 ± 6.41 a
10X10	31.2 ± 2.99 a	52.0 ± 4.43 a	35.6 ± 4.43 a	52.3 ± 13.53 a	21.4 ± 9.22 a
10X15	30.0 ± 4.31 a	52.9 ± 6.07 a	35.7 ± 6.07 a	46.3 ± 23.25 a	20.7 ± 7.06 a
10X20	30.5 ± 5.09 a	55.8 ± 5.06 a	34.8 ± 5.06 a	35.4 ± 11.59 a	21.9 ± 8.01 a
15X20	34.2 ± 4.31 a	62.4 ± 7.76 a	41.3 ± 7.76 a	36.1 ± 6.10 a	22.3 ± 6.04 a
20X20	33.7 ± 5.34 a	70.3 ± 4.22 a	39.0 ± 4.22 a	48.0 ± 18.26 a	25.5 ± 4.40 a
Numbers of cloves per hole					
1	12.4 ± 1.95 a	29.4 ± 8.79 a	14.2 ± 2.47 a	47.1 ± 19.41 a	25.5 ± 7.44 c
2	26.0 ± 3.63 b	55.0 ± 19.51 b	30.8 ± 4.74 b	43.2 ± 10.96 a	24.2 ± 8.66 bc
3	37.3 ± 5.41 c	64.5 ± 18.08 bc	43.9 ± 5.98 c	44.1 ± 13.09 a	19.0 ± 5.52 ab
4	49.0 ± 7.85 d	73.1 ± 26.08 c	56.7 ± 9.12 d	43.8 ± 13.48 a	15.9 ± 5.80 a

Numbers followed by the same letter were not significantly different based on Tukey's HSD ($p < 0.05$). Data were collected from 10 sample plants per plot

The elongation on pseudo-stem height and leaf length in the denser population in one planting hole may due to competition on light in that site. Li et al. (2017) stated that the competition in obtaining resources for plant growth can encourage change in energy allocation to certain parts of the plants according to their needs. Sufyati et al. (2006) also reported that the addition of shallot seed bulb per planting hole up to three bulbs per hole increased shallot plant height or leaf length.

In contrast to the increase in roots length and plant height, the addition of seed cloves per planting holes decreased the average weight of plant biomass (*Table 3*). The more plant emerged from the same planting hole led to higher competition in obtaining nutrition and light in this site, hence, the growth of garlic in such denser population was not optimal. Even though the pseudostem and leaf length was longer, they became thinner.

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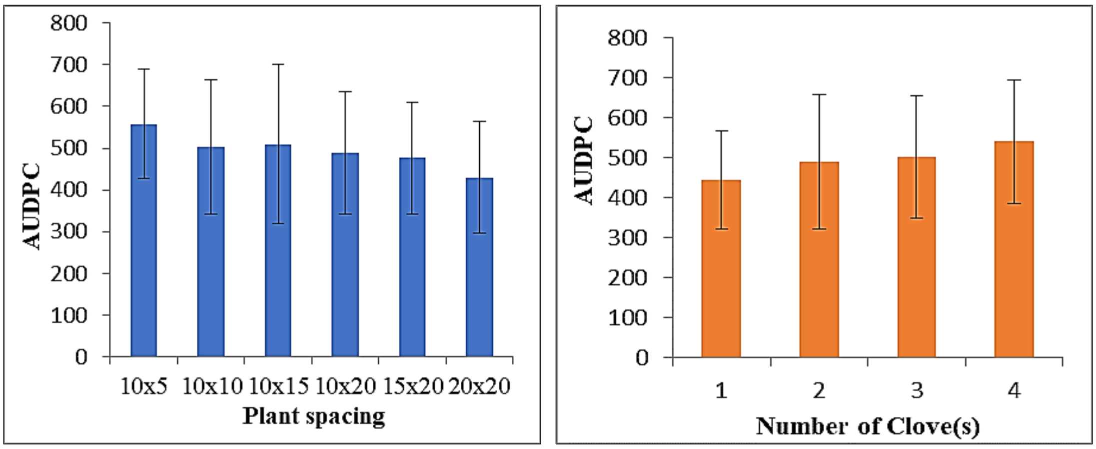
Effect of plant spacing and number of cloves per planting holes on purple blotch disease of garlic

Plant density usually affects microclimate within the plantation so that it can also influence the development of plant disease. In this study, purple disease was started to appear at 4 WAP. In this study, the plant spacing and the number of cloves per planting hole tested did not significantly affect purple blotch disease (*Table 2*). However, the development of the disease (AUDPC value) tended to increase with narrower plant spacing and higher number of cloves planted per hole (*Fig. 1*). No significant effect of plant population in this study may be related to the type of the garlic shoot which is relatively slender and hence the sun light was still able to penetrate within the relatively dense crops. Vidal et al. (2018) stated that plant morphology or plant canopy can affect the severity of plant diseases. Plant morphology with upright and compact growth offers avoidance of the disease (McDonald et al., 2013).



(A) (B)

Figure 1. *The effect of plant spacing (A) and number of garlic clove per planting hole (B) on purple blotch disease in garlic plants*

In addition to the microclimate, the macroclimate also plays a major role in the development of purple blotch disease. The average temperature during this study was approximately 21°C, humidity 87.46% with an average rainfall of 7.8 mm. The optimum temperature conditions for the development of purple blotch disease are 25-30°C (Sandrakirana et al., 2018). The relatively cool temperature at the time of study was not highly conducive for the development of purple blotch disease and therefore the difference between the treatments were not significant. The relatively cool condition at the experimental site was mainly related to the altitude of the location, which is in high land area (1250 m above sea level) with temperature range 15.8-25.7°C. In another experiment conducted during rainy season, plant spacing in Lumbu Hijau and some other garlic varieties with different clove size also did not show significant effect on purple blotch disease development in garlic (Krestini et al., 2019).

Effect of plant spacing and number of seed cloves per planting hole on the garlic yields

The statistical analysis showed that there was no significant effect of interaction between plant spacing and the numbers of garlic cloves per planting holes on some yield

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variables such as the diameter and weight of garlic bulbs and the number of cloves per bulb. However, there was an interaction between plant spacing and the number of cloves per planting hole in influencing the garlic yield (*Table 4*). When the number of clove planted per hole was only one, the garlic yield in all spacing treatment was not significantly different. The effect of spacing in yield was more obvious when the numbers of seed cloves per planting hole was more than one (*Table 5*).

***Table 4.** The results of variance analysis in various garlic yield variables*

Source	Degree of freedom	Significance values			
		Average of bulb diameter	The weight of bulb per plant	Average numbers of cloves per bulb	The weight of garlic bulb per plot
Replication	2	0.830	0.854	0.869	0.143
Spacing	5	0.800	0.893	0.453	0.012
Error of main plot	10				
Numbers of Cloves	3	0.073	0.247	0.284	0.000 **
Spacing x Cloves	15	0.098	0.203	0.292	0.034
Error of sub plot	36				
Total	71				

***Table 5.** The effect of spacing and number of cloves per planting hole on garlic yield per plot*

Spacing (cm)	The weight of garlic bulb per plot (kg/plot)			
	Number of cloves per hole			
	1	2	3	4
10x5	1.450 ± 0.60 a A	1.640 ± 0.32 a A	2.050 ± 0.07 a A	1.800 ± 0.17 a A
10x10	1.433 ± 1.19 a A	2.133 ± 1.00 ab A	1.930 ± 1.10 a A	2.340 ± 0.85 a A
10x15	1.333 ± 0.33 a A	4.267 ± 0.93 b B	2.457 ± 0.58 a AB	3.303 ± 1.20 a AB
10x20	2.397 ± 0.21 a A	2.530 ± 1.73 a A	4.140 ± 0.47 ab AB	2.443 ± 0.96 a A
15x20	1.550 ± 0.87 a A	2.123 ± 1.15 ab AB	5.043 ± 1.06 b C	4.190 ± 0.89 ab BC
20x20	1.940 ± 1.48 a A	1.780 ± 0.51 ab A	2.887 ± 1.36 ab A	4.007 ± 2.24 ab AB

The mean value followed by the same letter was not significantly different according to the Tukey HSD test at a significance level of 0.05. Lowercase letters are read in a vertical direction comparing 2 distances on the same number of plants. Capital letters are read horizontally, comparing 2 numbers of plants at the same distance

Combination of plant spacing and the number of clove per planting hole determine plant population and density. In general, the optimal plant density supports optimum plant growth leading to maximum yield. The combination that led to higher garlic yield were found in 10x15 cm spacing with two cloves (768,000 plants/ha) and spacing 15x20 cm with three cloves per planting hole (864,00 plants/ha) (*Table 5*). The results of previous study showed that the optimal density of garlic was 600,000-750,000 plants/ha

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(Moravčević et al., 2011). The differences in the optimal population supporting garlic yield were probably due to the differences in the varieties of garlic used.

In this study, plant spacing and the number of cloves per hole affected the garlic yield per plot. However, they did not affect the development of garlic bulb per plant. Observation on garlic bulb per plant showed that there was no significant difference on the diameter of bulb, the weight and the numbers of cloves per bulb in all treatments examined (*Table 6*). Even though there was reduction on plant biomass when the number of clove was increased, it did not result in significant effect on the development of garlic bulb per plant. In this study, the garlic bulbs produced were relatively small and therefore their development was not affected by the plant density examined.

Table 6. *The effects of plant spacing and the number of cloves per planting hole on the yield per plant*

	Average of bulb diameter (mm)	**The weight of bulb per plant (g)**	**Average numbers of cloves per bulb**
Plant spacing (cm)			
10X5	20.29 ± 0.88 a	7.79 ± 1.00 a	10.13 ± 3.53 a
10X10	20.87 ± 1.65 a	7.93 ± 2.24 a	10.95 ± 2.58 a
10X15	21.47 ± 1.68 a	8.49 ± 1.84 a	9.78 ± 1.61 a
10X20	21.26 ± 1.87 a	8.34 ± 2.83 a	8.82 ± 3.88 a
15X20	20.99 ± 2.95 a	7.74 ± 2.66 a	8.35 ± 3.27 a
20X20	21.32 ± 3.23 a	8.63 ± 3.66 a	9.53 ± 4.78 a
Number of cloves per hole			
1	21.91 ± 1.87 a	8.34 ± 2.05 a	8.41 ± 2.67 a
2	20.89 ± 2.41 a	7.78 ± 2.35 a	9.22 ± 3.60 a
3	21.57 ± 1.38 a	9.20 ± 2.52 a	10.96 ± 2.07a
4	19.77 ± 2.50 a	7.29 ± 2.55 a	9.79 ± 4.77 a

Numbers followed by the same letter were not significantly different based on Tukey's HSD ($p < 0.05$)

The arrangement of plant density or plant population basically is an effort to optimize the use of resources supporting the maximum production per unit area. The higher number of plant population can increase the yield, however it may also have negative impact due to plant competition for water, nutrients and light (Postma et al., 2020). The yield tends to increase with the increase on plant population up to a certain level and afterwards it may decrease. In this study, combination of spacing 10x15 cm with two cloves per hole or spacing of 15x20 m with three cloves per holes led to a garlic yield per plot which was 3.2-3.8 fold compared to the yield produced with the farmer's common practice, which is 10x15 cm plant spacing with one clove per hole (Sandrakirana et al., 2018). This means that doubling or the addition of the seed cloves per planting hole increased the number of plants per unit area leading to the production of extra yield per unit area. In that combination, the increase in plant population lead to more efficient use of space without resulted in high competition effects. In this experiment, the increase in plant density did not affect the garlic bulb per plant.

The highest yield per plot (5.043 kg) was actually found in the treatment, spacing 15x20 cm with three cloves per planting hole. However, the numbers of seed cloves required was higher, while the yield was not significantly different. Concerning that, the spacing of 10x15 cm with two cloves per hole was selected as it is more efficient.

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The result of the second experiment showed that doubling the number of clove per planting hole with plant spacing 10x15 cm did not significantly affect the garlic growth. Growth variables such as the pseudostem height and the numbers of leaves in the treatment of one or two cloves per planting hole were not significantly different (*Table 7*).

Table 7. *The effect of number of clove per planting hole on the garlic growth*

Number of clove per planting hole	**4 weeks after planting**		**11 weeks after planting**	
	Number of leaves	Height of pseudostem (mm)	Number of leaves	Height of pseudostem (mm)
1	5.20 ± 0.91 a	53.10 ± 43.85 a	5.53 ± 1.30 a	99.23 ± 22.84 a
2	5.35 ± 1.12 a	44.07 ±11.07 a	5.25 ±1.28 a	90.13 ± 22.00 a

Numbers followed by the same letter were not significantly different based on t test ($p < 0.05$). Data were collected from five sample plants per plot (100 sample plants in total)

Doubling the number of cloves per planting hole with plant spacing 10x15 cm affected several variables of the garlic yield. Planting two cloves per hole reduced the numbers of cloves per bulb and the weight of bulb per plant (*Table 7*). This may be related to the competition in obtaining water and nutrition supporting the development of bulb. However, the addition of clove per planting hole significantly increased garlic yield per plot (*Table 8*), which confirmed the result of the previous experiment.

Table 8. *The effect of number of clove per planting hole on the garlic yield*

Number of clove per planting hole	**Bulb diameter (mm)**	**The numbers of cloves per bulb**	**The weight of bulb per plant (g)**	**The weight of bulb per plot (kg)**
1	32.59 ± 5.77 a	7.34 ± 0.35 b	15.55 ± 6.36 b	1.931 ± 0.532 a
2	31.32 ± 5.19 a	6.37 ± 0.90 a	12.78 ± 5.21 a	4.457 ± 1.055 b

Numbers followed by the same letter were not significantly different based on t test ($p < 0.05$)

Overall result of this study showed that management of garlic plant population through the arrangement of plant spacing and the number of clove per planting hole could increase the garlic yield per unit area. Planting two garlic cloves per hole with plant spacing (10x15 cm) increased the yield per unit area up to 2.3-3.2 folds, compared to the yield of the common practice which used the same plant spacing with one clove per planting hole. The increase in the garlic yield per plot seems due to the increase on the plant population.

The result of second experiment also showed that even though doubling the cloves per hole resulted in relatively smaller garlic bulb, actually the average weight of the cloves was similar to the cloves produced in the treatment with one clove per planting hole. The average weight of the garlic cloves in those treatments were 2.0 g and 2.1 g respectively. The relatively smaller garlic bulbs can be compensated by the increase in the yield per unit area. Based on the result, doubling the garlic seeds per planting hole with 10x15 cm plant spacing can be recommended for increasing garlic productivity.

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Conclusion

Result of this study showed that plant spacing did not significantly affect the garlic growth. However, the increase in number of cloves per planting hole enhanced root and leaf length as well as pseudostem height of garlic, but reduced plant biomass. Plant spacing and the numbers of cloves examined did not significantly affect the development of purple blotch disease. Combination of plant spacing and the number of bulb per planting hole affected the garlic yield per plot. In Lumbu hijau cultivar, spacing of 10x15 cm with two cloves per hole (equivalent to 768.000 plants/ha) increased the garlic yield per unit area 2.3-3.2 fold, compared to the common practice in Indonesia (10x15 cm plant spacing with one clove per hole).

Conflict of Interests. The authors declare that there is no conflict of interests.

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