Effect of plant spacing and pest controls of *Spodoptera exigua* on shallots in Majalengka Regency, West Java

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Abstract. This study examines the spacing and control of Spodoptera exigua pests on shallot plants in West Java. The research was conducted in Payung Village, Rajagaluh District, Majalengka Regency, West Java from September to November 2018. The study used a randomized complete block design with a total of four treatments and six replications. The treatments consisted of 1) spacing 15 x 20 cm + traps, 2) spacing 18 x 20 cm + traps, 3) spacing 20 x 20 cm + traps, and 4) spacing 20 x 20 cm + chemical. Data were analysed using the F test and followed by the Duncan test at the 95% confidence level. The results showed that the treatment of 18 x 20 cm spacing + traps resulted in the highest productivity of shallots compared to other treatments, namely 13.5 tons per hectare. The use of sex pheromone traps was more effective in controlling S. exigua pests than light traps and yellow traps.

1 Introduction

Shallots are one of the leading horticultural commodities that have high economic value in West Java. Shallot centers in West Java based on the amount of production in 2019 are Bandung Regency, Majalengka Regency, Cirebon Regency, and Garut Regency [1]. The main pest problem of shallots, namely shallot caterpillar (*Spodoptera exigua*) often causes losses because it can reduce yields and even crop failure. *S. exigua* is the main pest of shallots with attacks throughout the year, both in the rainy and dry seasons [2]. The symptoms due to *S. exigua* attack were the presence of transparent white spots on shallot leaves due to the leaf flesh inside the leaf cavity being eaten by *S. exigua* larvae and leaving an epidermal layer and if the attack was heavy the entire leaf was eaten [3].

So far, insecticides have been used to control these pests and even excessive use has the potential to pollute the environment. Shallot farmers carry out pest control techniques of *S. exigua* with insecticides at high doses and short spray intervals, and use a mixture of more than two types of pesticides [4]. Environmentally friendly cultivation technology with traps such as sex pheromones, light traps, and yellow traps can be one solution to control *S. exigua* pests. Currently, sex pheromonoid has been produced to monitor population and mass capture of male *S. exigua* insects in shallot cultivation. According to Haryati and Nurawan [5] the

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application of sex pheromones in shallot cultivation was able to reduce the use of insecticides >60% when compared to the use of calendar system insecticides.

The use of proper spacing can optimize plant growth and productivity. Plant spacing that is too tight has the potential to cause competition between plants and environmental factors to grow, allowing competition between plants to grow with the environment, while spacing that is too wide causes the utilization of growing space to be not optimal [6]. Plant density which is regulated to a certain extent, can efficiently determine the growing environment [7]. The closer the spacing, the lower the yield of fresh bulbs and dried bulbs per plant [8]. The existence of competition between plants for nutrients and sunlight causes a decrease in plant performance [9]. The highest weight of shallot bulbs was produced at 20 x 20 cm and 20 x 25 cm spacing treatments accompanied by 3 times weeding [10]. Spacing of 10 x 25 cm resulted in the highest number of leaves per clump, the number of bulbs per clump, fresh weight of bulb per clump, and the highest weight of stored dry bulb per clump [11]. This study aimed to examine the spacing and control of *S. exigua* pests on shallots in Majalengka Regency, West Java.

2 Materials and methods

The study conducted at Payung Village, Majalengka Regency, West Java in September to November 2018. The study used a Randomized Complete Block Design (RCBD) with four treatments and six replications. Treatment consists of: 1) plant spacing of 15 x 20 cm + traps; 2) plant spacing of 18 x 20 cm + traps; 3) plant spacing of 20 x 20 cm + traps; and 4) plant spacing of 20 x 20 cm + chemical insecticide. Various spacings used were based on the habits of farmers in the study location. The size of treatment plot was 2.000 m^2.

The shallot variety used was Batu Ijo. The organic and inorganic fertilizers given consisted of basic fertilizer given 7 days before planting consisting of manure 10 tons/ha, 380 ZA kg ha^{-1}, 330 SP-36 kg ha^{-1}, 200 kg/ha and supplementary fertilizer 370 Urea kg ha^{-1} given 15 days after planting (DAP) and 35 DAP, half the dose each.

Traps for *S. exigua* using sex pheromones, light traps, and yellow traps. The number of sex pheromones is 10 units, light traps 2 units and yellow traps 15 units. Sex pheromones were installed before planting, while light traps and yellow traps were installed 3 DAP. The water in the pheromone trap is changed every three days. Observations of *S. exigua* were carried out up to 16 times with an interval of 3 days starting when the plants were 6 DAP. Chemical insecticide treatments to control *S. exigua* were carried out at 5-day intervals from the vegetative phase to 10 days before harvest.

The variables observed were plant height, number of tillers per clump, weight of wet and dry stover per clump, weight of dry bulb per clump, yield, and percentage of damage due to pest attack.

The percentage of attacks is calculated using the following formula:

$$P = \frac{N}{N} x \; 100\%$$

P = percentage of attacks
n = number of affected or damaged clumps
N = number of observed clumps
Data were analyzed by F test and continued with Duncan's test at 95% confidence level.

3 Result and discussion

At the age of 20, 30, and 40 DAP, plant spacing of 15 x 20 cm + traps and plant spacing of 18 x 20 cm + traps produced the highest plant height while plant spacing of 20 x 20 cm + traps produced the lowest plant height (Table 1). The closer spacing in treatment of plant spacing of 15 x 20 cm + traps were thought to have resulted in the emergence of competition among plants in obtaining growth space, nutrients, light, and water. The closer the spacing, the faster the plant height growth because the plants seek lighter. Spacing treatment affects plant height [7]. The closer spacing in the Bima variety causes the shallot plants to be taller than the wider spacing [6]. A closer spacing of 10 x 15 cm resulted in the highest shallot plant height [12]. At closer spacing, it is possible to compete with light so as to stimulate the growth of shallots' height [13].

Table 1. Effect of spacing and pest control of *Spodoptera exigua* on shallot plant height

Treatment	**Plant height at age (cm)**			
	10 DAP	**20 DAP**	**30 DAP**	**40 DAP**
plant spacing of 15 x 20 cm + traps	35.30 a	40.20 a	43.60 a	50.20 a
plant spacing of 18 x 20 cm + traps	33.20 a	40.00 a	43.00 a	50.20 a
plant spacing of 20 x 20 cm + traps	29.82 a	34.00 b	35.32 b	39.68 b
plant spacing of 20 x 20 cm + chemical	32.46 a	37.00 ab	39.00 ab	45.76 ab

The numbers in the same column followed by the same letter are not significant at the 5% test level (Duncan's test)

There was no significant difference at all ages of observation from all treatments to the number of tillers per clump (Table 2). Similar results were obtained in the study of Ayu et al. [6] which shows that there is no effect of spacing on the number of tillers.

Table 2. Effect of spacing and pest control of *Spodoptera exigua* on the number of tillers per red shallot clump

Treatment	**Number of tillers per clump at age (clump)**			
	10 DAP	**20 DAP**	**30 DAP**	**40 DAP**
plant spacing of 15 x 20 cm + traps	5.00 a	6.40 a	6.60 a	6.80 a
plant spacing of 18 x 20 cm + traps	4.00 a	5.00 a	5.32 a	5.00 a
plant spacing of 20 x 20 cm + traps	4.00 a	4.60 a	4.80 a	5.20 a
plant spacing of 20 x 20 cm + chemical	3.26 a	3.50 a	4.50 a	4.50 a

The numbers in the same column followed by the same letter are not significant at the 5% test level (Duncan's test)

Plant spacing of 18 x 20 cm + traps resulted in higher dry stover weight per clump and dry bulb weight per clump, while the number of bulbs per clump was not significantly different between all treatments (Table 3). There was a tendency for wider plant spacing to have a higher dry weight of stover and dry bulb weight per clump than those with a closer spacing. At this spacing, it is suspected that plants are able to utilize resources from the existing growing environment such as nutrients, light and water so that they affect plant growth. According to Ayu et al. [6], at wider spacings that have fewer populations, the potential for plant competition to take advantage of space and the growing environment is lower compared to closer spacings with larger populations.

Table 3. Effect of plant spacing and pest control of *Spodoptera exigua* on number of bulbs per clump, weight of dry stover per clump, and weight of dry bulb per clump of shallots

Treatment	Number of bulbs per clump (fruit)	Weight of dry stover per clump (g)	Dry bulb weight per clump (g)
plant spacing of 15 x 20 cm + traps	6.40 a	27.90 b	23.28 b
plant spacing of 18 x 20 cm + traps	6.00 a	38.38 a	34.84 a
plant spacing of 20 x 20 cm + traps	6.33 a	33.84 ab	30.72 ab
plant spacing of 20 x 20 cm + chemical	4.75 a	28.23 b	25.46 b

The numbers in the same column followed by the same letter are not significant at the 5% test level (Duncan's test)

The highest results were obtained in plant spacing of 18 x 20 cm + traps (Table 4). This shows that, a spacing of 18 x 20 cm is the optimal spacing for high yields. At this spacing, it is suspected that there is no competition between plants so that plants are able to grow optimally and produce higher production. In addition, the high yield obtained in treatment B was also supported by the weight of the stover per clump and the weight of the bulbs per clump. Aziz et al. [14] reported that the weight of the stover is one of the characters that can directly increase the weight of the shallot bulbs. The results of research by Hamdani and Susanto [15] showed that there was a strong correlation between the weight of the stover and the weight of bulbs per clump of shallots.

Table 4. Effect of spacing and pest control of *Spodoptera exigua* on shallot yield

Treatment	Yield (tons)
plant spacing of 15 x 20 cm + traps	9.50 d
plant spacing of 18 x 20 cm + traps	13.50 a
plant spacing of 20 x 20 cm + traps	10.30 c
plant spacing of 20 x 20 cm + chemical	11.98 b

The numbers in the same column followed by the same letter are not significant at the 5% test level (Duncan's test)

The percentage of *S. exigua* attack in the treatment using traps (sex pheromone, light trap, yellow trap) at the age of 30 DAP was 9-5-11% while those using chemical insecticides reached 24%. The use of traps seems to be more effective in overcoming *S. exigua* pests. Moekasan et al. [3] stated that catching these moths was more effective and efficient than routine insecticide spraying, especially to set control thresholds.

Table 5. Percentage of *Spodoptera exigua* attack on shallot plants aged 30 DAP

Treatment	Attack percentage (%)
plant spacing of 15 x 20 cm + traps	11.00%
plant spacing of 18 x 20 cm + traps	11.00%
plant spacing of 20 x 20 cm + traps	9.50%
plant spacing of 20 x 20 cm + chemical	24.80%

S. exigua pest control through traps was more effective using sex pheromones, because almost no pests were caught by light traps and yellow traps during this study. It is suspected that sex pheromones are special attractants that are selective for controlling *S. exigua* pests. The average population of the highest *S. exigua* moth caught in the sex pheromone was 5.9 individuals, when the shallot plants were 18 DAP (Table 6). In addition to functioning to reduce the level of *S. exigua* pest attack, trapping technology can be used to determine the presence of *S. exigua* imago populations in an expanse of shallot plants which can then be used as a benchmark for controlling using pesticides. The use of traps is an environmentally friendly method of controlling *S. exigua*. According to Haryati and Agus [5] pheromones are chemical substances produced from the endocrine glands and are used to recognize others in helping the reproductive process. The results of the research by Resmayeti and Samudera [16] showed that pest control based on imago catches >10 individuals per day through traps before pesticide treatment could increase the yield and income of shallot farmers compared to controlling by spraying pesticides every 3 days.

Table 6. Observations of the *S. exigua* moth caught in the trap

Observation to	Number of *S. exigua* moths (tail)		
	Sex pheromones	Light trap	Yellow trap
1	2.2	-	-
2	3.8	-	-
3	5.0	-	-
4	3.2	-	-
5	5.9	-	-
6	3.4	-	-
7	1.8	-	-
8	1.0	-	-
9	1.3	-	-
10	1.0	-	-
11	1.0	-	-
12	1.6	-	-
13	1.6	-	-
14	1.6	-	-
15	1.6	-	-
16	1.3	-	-

4 Conclusion

The plant spacing of 18 x 20 cm + trap resulted in the highest productivity of shallots compared to other treatments, namely 13.5 tons ha^{-1}. The average damage to shallot plants due to *S. exigua* pests in the treatment using traps is 9.5-11% while using insecticides reaches 24%. The use of sex pheromone traps was more effective in controlling *S. exigua* than light traps and yellow traps.

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