Short Research Article
The Effect of Plant Spacing and Weeding Time on The Growth and Yield of Cucumber (*Cucumis sativus* L.)

ABSTRACT

The need for cucumbers continues to increase in line with the increase in population, living standards, education level and public awareness of the importance of nutritional value. Increasing cucumber crop production continues to be carried out through improved cultivation techniques, such as planting distance and weeding time. This study aims to determine the effect of various planting distances and weed weeding time on the growth and production of cucumber plants. This study used a factorial Group Randomized Design and three repeats. The factors studied consist of planting distance (J), namely planting distance 30 cm x 60 cm (J1), planting distance 40 cm x 60 cm (J2), and planting distance 50 cm x 60 cm (J3). Weeding time (W) treatment consists of weeding time 2 WAP (W1), weeding time 2 and 4 WAP (W2), and weeding time 2, 4 and 6 WAP (W3). The results showed that Plant distance and weeding time influence the growth and yield of cucumber plants. The combination of treatment with a planting distance of 40 cm x 60 cm and weeding two times (2 and 4 WAP) is the best treatment for influencing the growth and yield of cucumber plants. Weeding two times (2 and 4 WAP) was not significantly different from weeding three times (2, 4 and 6 WAP) on the growth and yield of cucumber plants. The highest SDR was at 40 x 60 cm planting distance (J2), which was 62.35%.

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Ensure you strickly adhere to author's guidelines.

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Keywords: Cucumbers, planting distance, weeding time, growth and production,, summed dominance ratio (SDR).

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1. Introduction

The Cucumber (Cucumis sativus L.) is an important vegetable crop grown extensively across Southeast Asia for its nutritious and antioxidant-rich fruits. Achieving optimal productivity of cucumber relies heavily on suitable agronomic practices including proper plant spacing and timely weed control [1]. Wider spacing between cucumber plants reduces competition for growth resources like light, soil moisture and nutrients. However, it also lowers plant population density, reducing yields per land area [2]. Similarly, timely weeding is critical as weeds intensely compete with the crop, with

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yield losses of 40-80% reported in uncontrolled fields [3]. Integrating optimal plant spacing and weeding regimes is therefore imperative to maximize cucumber productivity in Southeast Asia.

Their interaction affects crop yields based on agroecological principles of growth resource competition described by the Summed Dominance Ratio (SDR) concept. SDR analysis relates crop yield to the total plant density and relative crop-weed densities in an additive model [4]. This study evaluated cucumber yield responses to different planting distances and weed control timing using SDR analysis to determine optimal integrated crop management practices for maximizing cucumber productivity across diverse agro-ecological contexts in Southeast Asia.

Cucumber fruits contain 95% water and are low in calories, while providing sufficient vitamins, minerals and antioxidants vital for human health [5]. Their global production reached 83 million tons from 2 million hectares in 2017, with Asia accounting for over 70% of total output. In Southeast Asia, cucumber is ranked amongst the top five most cultivated vegetables owing to huge domestic demand, commercial viability and export market prospects[6]. However, average productivity in the region is below 10 tons/ha against the global average of over 30 tons/ha[7]. Narrowing these yield gaps through agricultural innovation adoption is therefore imperative to meet rising regional demands.

Several factors responsible for low productivity have been identified but weed infestation and sub-optimal plant densities are the major constraints [1]. Crop yields ranging from 40-80% losses highlight the negative impacts of weed competition [8]. Similarly, inappropriate planting distances increase interplant competition for resources, suppressing growth and yield [9]. Integrating the two aspects through optimization of spacing and weeding therefore provides a feasible solution to improve cucumber productivity amidst growing regional demands and limited land resources. This study provides key insights on the interaction of plant spacing and weeding regimes towards maximizing cucumber yields in Southeast Asia to support food and nutritional security.

2. Materials and methods

This research was carried out from November 2022 to January 2023 at the Experimental Garden of the Faculty of Agriculture, University of Baturaja, using a factorially arranged Group Random Design and three repeats. The factors studied consist of planting distance (J), namely planting distance 40 cm x 60 cm (J1), planting distance 50 cm x 60 cm (J2), planting distance 60 cm x 60 cm (J3). Weeding time (W) treatment consists of weeding time 2 WAP (W1), weeding time 2 and 4 WAP (W2), and weeding time 2, 4 and 6 WAP (W3).

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The land used is first processed until loose, then plots are made with a length of 200 cm, width of 100 cm, height of 30 cm and distance between maps of 50 cm. Cucumber seeds of the Hercules variety are inserted into planting holes with as many as two grains in each planting hole, then covered with soil 1 cm thick. The planting distance

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used is by the treatment. The vines, or “para-para”, are installed when the cucumber plant is 14 days old after planting with a creeping height of 150 cm [10].

The inorganic fertilizer used is compound NPK fertilizer 16:16:16 applied after the eastern plants are 7 DAP at a dose of 1 g/plant (100 kg/ha) and additional fertilizer is given when the cucumbers are 21 DAP at a dose of 1 g/plant. The method used in this fertilization is a circular system for each plant [11].

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Fertilization using compound NPK fertilizer 16:16:16, carried out twice, namely when the plants are 7 DAP and 21 DAP with each dose of 1 g per plant (100 kg ha-1), fertilizer is given by immersing it around the plant [11]. Leaf pruning is done when the leaves are too dense. Watering is done twice a day in the morning and evening. Replanting is done when the plants are seven days after planting. Harvest five times; the first harvest is carried out when the plants are 40 days after planting, with a harvest interval of 5 days from the previous harvest. The parameters observed in this study were plant height (cm), shoot dry weight (g), number of fruit (fruit),fruit weight per plant (kg), and analysis summed Dominance Ratio (SDR).

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Data analysis in this study used Analysis of variance to determine the effect of treatment given using SPSS 17.0. It continued the 5% LSD test to determine the difference between treatments on the observed parameters.

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3. Results

The results of the diversity analysis (Table 1) shows the analysis of variance (ANOVA) to determine the effect of planting distance, weeding time, and their interaction on various cucumber growth and yield parameters. The observed variables were plant height (cm), canopy dry weight (g), number of fruits (pieces), and fruit weight (g). The asterisk (*) indicates that the effect of the respective treatment (planting distance, weeding time, or their interaction) is statistically significant on that variable.

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The Anova results demonstrate that planting distance, weeding time, as well as their interaction had a significant (P<0.05) impact on all variables tested - plant height, canopy dry weight, number and weight of cucumber fruits. This highlights that both spacing and weeding regimes play an important role, independently and jointly, in influencing the growth and yields of cucumber. Optimal practices for these two aspects are essential to improve productivity.

Table 1. Analysis of Variance

Variable	Planting distance	Weeding time	Interaction
Plant height (cm)	*	*	*
Canopy Dry weight (g)	*	*	*
Number of fruits (pieces)	*	*	*
Fruit weight (g)	*	*	*

Remarks : * : significant

3.1. Plant length

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Table 2 shows the effect of planting distance and weeding time on cucumber plant length (cm) at final harvest. Three planting distances were used: 40 cm x 60 cm (J1), 50 cm x 60 cm (J2) and 60 cm x 60 cm (J3). Weeding was done at three frequencies: 2 WAP (W1), 2 and 4 WAP (W2), and 2, 4 and 6 WAP (W3). The tallest plants measuring 252.93 cm were recorded with a spacing of 50 cm x 60 cm (J2) and weeding at 2, 4 and 6 WAP (W3). The shortest plants (187.13 cm) resulted from spacing of 40 cm x 60 cm (J1) and weeding only once at 2 WAP (W1).

Table 2. Plant length

Planting Distance	Planting time		
	W1	W2	W3
40 x 60 cm (J1)	187.13 a	206.13 abc	224.20 cd
50 x 60 cm (J2)	192.06 ab	247.80 cd	252.93 d
60 x 60 cm (J3)	208.66 abc	223.46 bcd	200.13 abc

a,b,c,d: The different letters in columns are significantly different between treatments (P>0.05).

Different letters (a,b,c,d) indicate significant differences between the treatment means based on LSD at 5% level (P<0.05). The results showcase that wider spacing of 50 cm x 60 cm coupled with adequate weeding at 2, 4 and 6 WAP helps achieve superior plant growth. Proper spacing and weeding practices are vital for optimal cucumber performance.

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3.2. Canopy Dry Weight

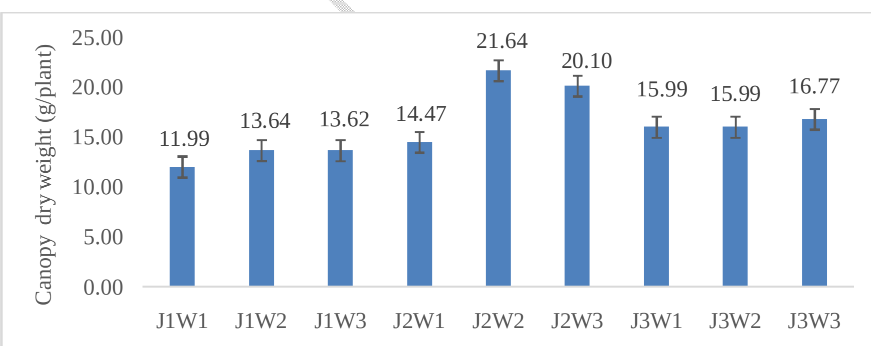

Fig. 1. The effect of planting distance and weeding time on the dry weight of Cucumber plant canopy (Cucumis sativus L.) at the end of the study g/plant). J1: planting distance 40 cm x 60 cm, J2: planting distance 50 cm x 60 cm, J2: planting distance 60 cm x 60 cm, W1: weed weeding time (2 WAP), W2: weed weeding time (2 and 4 WAP), W3: weed weeding time (2, 4 and 6 WAP).

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The bar chart depicts the effect of planting distance and weeding time on the cucumber's canopy dry weight (g/plant) at the final harvest (Figure 1). Three planting distances, 40x60cm (J1), 50x60cm (J2), and 60x60cm (J3) were tested. Weeding was done at three frequencies: 2 WAP (W1), 2 and 4 WAP (W2), and 2, 4, and 6 WAP (W3). The combined treatment of 50x60 cm spacing (J2) and weeding at 2 and 4 WAP (W2) resulted in the highest canopy dry weight of 21.64 g/plant. In contrast, 40x60cm spacing (J1) and weeding only once at 2WAP (W1) produced the lowest dry weight of 11.99 g/plant.

Overall, there is a clear tendency for higher canopy biomass with a wider spacing of 50 cm and adequate weeding at 2 and 4 WAP. Insufficient weeding frequency negatively affects growth. Optimizing spacing and weeding regimes is critical for improving cucumber canopy development and productivity.

3.3. Number of Fruits

Table 3 shows the effect of planting distance and weeding time on number of cucumber fruits per plant. Three planting distances were used: 40 cm x 60 cm (J1), 50 cm x 60 cm (J2), and 60 cm x 60 cm (J3). Weeding was done at three frequencies: 2 WAP (W1), 2 and 4 WAP (W2), and 2, 4, and 6 WAP (W3).

The highest number of fruits per plant (8.26) was obtained with a planting distance of 50 cm x 60 cm (J2) and weeding at 2 and 4 WAP (W2). This was significantly higher than all other treatments as indicated by different letters (e).The lowest fruit number (6.40 per plant) resulted from planting distance of 60 cm x 60 cm (J3) and weeding only at 2 WAP (W1).

Statistical analysis showed that planting distance, weeding time and their interaction all had a significant effect ($P>0.05$) on number of cucumber fruits per plant. Proper spacing and adequate weeding are essential for achieving higher fruit yields.

Table 3. Number of fruits

Planting Distance	Weeding Time		
	W1	W2	W3
40 x 60 cm (J1)	6.73 ab	7.33 cd	7.00 bc
50 x 60 cm (J2)	6.66 ab	8.26 e	8.13 e
60 x 60 cm (J3)	6.40 a	7.20 bc	7.80 de

a,b,c,d: The different letters in columns are significantly different between treatments ($P>0.05$).

3.4. Fruit weight

The table shows the effect of different planting distances and weeding times on the fruit weight per cucumber plant (g/plant) at the final harvest. Three planting distances were tested: 40 cm x 60 cm (J1), 50 cm x 60 cm (J2), and 60 cm x 60 cm (J3). Three weeding times were applied: 2 WAP (W1), 2 and 4 WAP (W2), and 2, 4, and 6 WAP (W3). The results show that planting distance 50 cm x 60 cm (J2) with 2 and 4 WAP weeding (W2) produced the highest fruit weight per plant (1047.33 g).

Table 4. Fruits weight

Planting Distance	Weeding Time		
	W1	W2	W3
40 x 60 cm (J1)	794.66 a	888.66 b	905.33 bc
50 x 60 cm (J2)	801.33 a	104.,33 e	100.,00 de
60 x 60 cm (J3)	868.00 b	954.00 cd	896.33 bc

a,b,c,d: The different letters in columns are significantly different between treatments (P>0.05).

On the contrary, planting spacing J1 and J2 at 2 WAP weeding (W1) resulted in the lowest fruit weights per plant of 794.66 g and 801.33 g, respectively. This indicates that a wider spacing of 50 cm x 60 cm coupled with timely weeding at 2 and 4 WAP is optimal for achieving higher cucumber fruit weights and productivity.The intermediate spacing of 60 cm x 60 cm (J3) also produced decent fruit weights but was not statistically at par with the top treatment of J2W2. Overall, the importance of integrating proper spacing and weeding for maximizing cucumber yields is clearly exhibited.

3.5. Analysis Summed Dominance Ratio (SDR)

This table shows the Summed Dominance Ratio (SDR) values for 3 different planting distance treatments, namely 40 x 60 cm (J1), 50 x 60 cm (J2), and 60 x 60 cm (J3). SDR measurements were taken 2 and 4 weeks after planting (WAP). At 2 WAP, the highest SDR was at 50 x 60 cm planting distance (J2), which was 62.35%. This indicates that the crops dominated weed growth the most at this planting distance compared to the other 2 treatments.

At 4 WAP, the 50 x 60 cm planting distance (J2) had the highest SDR of 64.73%. The remarks mention that manual weeding treatment was carried out after vegetation analysis. Based on these SDR results, this was probably done to suppress weeds in J2 and J3.

Table 5. Analysis Summed Dominance Ratio (SDR) in treatments planting distances.

Planting Distance	SDR (%)	
	2 WAP	4 WAP
40 x 60 cm (J1)	62.35	64.73
50 x 60 cm (J2)	58.38	57.66
60 x 60 cm (J3)	47.32	53.82

Remarks: Manual weeding treatment is carried out after vegetation analysis.

4. Discussion

Table 1 shows the analysis of variance for four variables: plant height, canopy dry weight, number of fruits, and fruit weight. The analysis categorized the effects into:

planting distance, weeding time, and their interaction. For all four variables - plant height, canopy dry weight, number of fruits, and fruit weight - the effects of planting distance, weeding time, and their interaction were statistically significant, as indicated by the (*) beside each. This means that each of these factors - planting distance, weeding time, and the interaction between the two - had a significant impact on all four dependent variables that were measured.

The effect of planting distance and weeding time on plant length (Table 2) shows three weeding times were tested: W1, W2, and W3. Plant lengths followed by different letters are significantly different at the p>0.05 level.The data shows that at the closest planting distance of 40 x 60 cm (J1), plant length increased from 187.13cm (W1) to 224.20cm (W3) as weeding time was delayed. This aligns with previous research stating that dense planting can intensify crop-weed competition, slowing growth over time [12].

The longest plants were obtained with the 50 x 60 cm (J2) spacing at the later W3 weeding time (252.93cm). This supports [13], who found wider row spacing reduces competition and facilitates growth if weeds are also managed. Finally, at the widest spacing of 60 x 60 cm (J3), an intermediate plant length of 223.46cm was achieved with just the W2 weeding time before decreasing, likely because the intraspecific competition was lowered, allowing faster early growth. Overall, the interaction between plant spacing and weeding timing significantly impacted plant length. Wider spacings reduced competitive pressure, but later weeding enhanced it. These trends validate other crop-weed competition studies. Further trials could test additional spacings and weed management timings.

The data shows the effect of planting distance and weeding time on canopy dry weight (measured in g/plant). Three planting distances were tested: J1 (40 x 60cm), J2 (50 x 60cm), and J3 (60 x 60cm). Additionally, three weeding times were tested: W1, W2, and W3. The highest canopy dry weight was obtained with the J2 (50 x 60cm) planting distance at the later W2 weeding time (21.64 g/plant). This aligns with previous findings showing that moderate planting densities can optimize crop growth and yield [14]. The wider spacing reduces competitive pressure compared to higher density planting, while later weeding times allow the crops to capitalize on available nutrients and light. The lowest canopy dry weights came from the J1 (40 x 60cm) dense planting at earlier W1 and W2 weeding times (11.99 g/plant and 13.64 g/plant). This fits with literature stating that intense intraspecific completion in dense stands causes mutual shading and depletion of nutrients over time if weeds are not managed promptly [15].

Overall, the interaction between plant spacing and weeding timing significantly influenced canopy dry weight. Moderate spacings with timely weed removal optimized crop growth. Further trials could compare additional row spacings and weeding regimes to determine the ideal combination for maximum canopy development.

Table 3 displays the effect of planting distance and weeding time on the number of fruits produced. Different letters indicate statistically significant differences between treatment means at the p>0.05 level. The most fruits were obtained with the widest 50 x 60 cm (J2) planting distance at later W2 and W3 weeding times (8.26 and 8.13 fruits). As [16] found, moderate plant spacing reduces competition pressure and

facilitates fruit production if weeds are properly controlled. The lowest fruit counts came from the closets 40 x 60 cm (J1) spacing weeded at W1 (6.73 fruits).
Overall, planting density and timing of weed control interacted significantly. Wider spacings reduced competitive pressure, while the W2-W3 weeding window allowed crops to achieve maximal fruit production before intraspecific effects intensified. Additional integrated weed management trials could further optimize yield.

Table 4 shows the effect of planting distance and weeding time on fruit weight (measured in grams). Different superscript letters denote statistically significant differences between means at the p>0.05 level. The highest fruit weights were achieved with the 50 x 60 cm (J2) spacing at the later W2 weeding (1041.33g). As [11] found, moderate plant densities can optimize yield components if weeds are managed appropriately. Wider spacings reduce competitive pressure while the W2 timing prevented excessive crop-weed interference.

The lowest fruit weights came from the narrowest 40 x 60 cm (J1) spacing at the earlier W1 weeding (794.66g). This aligns with literature stating dense stands exacerbate intraspecific competition for light and nutrients, decreasing yields without timely weed control [5]. In summary, planting distance and weeding timing interacted significantly to influence fruit weight. Wider row spacings reduced competitive pressure while the W2 timing allowed maximum fruit production before crop-weed effects intensified. Further integrated management trials could determine optimal configurations to enhance yield.

Table 5 displays the Summed Dominance Ratio (SDR) of crops at varying planting distances, measured at 2 and 4 weeks after planting (WAP). Higher SDR values indicate the crop is more dominant over weeds in the vegetation stand. The 40 x 60cm (J1) spacing maintained the highest SDR at both measurement times (62.35% and 64.73%), indicating the crop was most dominant over weeds. As [17] found, dense stands can initially suppress weed growth through rapid early establishment and competition for resources.

Meanwhile, the widest 60 x 60cm (J3) spacing exhibited lower SDR values at both timings (47.32% and 53.82%). Wider spacings reduce crop competition allowing more weed interference [18]. However, remarks indicate manual weeding was conducted after this 4 WAP vegetation analysis. Previous research shows well-timed weed control in moderately spaced crops helps optimize yield despite early weed pressure [19]. Further integrated management trials could test ideal planting and weeding regimes.

Conclusion

Plant distance and weeding time influence the growth and yield of cucumber plants. The combination of treatment with a planting distance of 40 cm x 60 cm and weeding two times (2 and 4 WAP) is the best treatment for influencing the growth and yield of cucumber plants. Weeding two times (2 and 4 WAP) was not significantly different from weeding three times (2, 4 and 6 WAP) on the growth and yield of cucumber plants. The highest SDR was at 40 x 60 cm planting distance (J2), which was 62.35%.

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