



HORTIN II Co Innovation Programme

Towards cost effective, high quality value chains

Effect of number of stems per plant on the growth and yield of four sweet pepper varieties

HORTIN-II Research Report nr. 23

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The purpose of the HORTIN-II programme is to contribute to the development of cost effective high quality value chains for vegetables and fruits. Among others this can be achieved when technology development takes place in close collaboration between public institutions, farmers and private companies.

On the Indonesian side the programme is carried out by the Indonesian Centre for Horticultural Research and Development (**ICHORD**), Jakarta, with the Indonesian Vegetable Research Institute (**IVEGRI**), Lembang, and the Indonesian Centre for Agricultural Postharvest Research and Development (**ICAPRD**) in Bogor.

In the Netherlands the Agricultural Economics Research Institute (**AEI**), Den Haag, the Agrotechnology and Food Sciences Group (**ASFG**), Wageningen, Applied Plant Research (**APR**), Lelystad, and WUR-Greenhouse Horticulture (**WUR-GH**), Bleiswijk, all partners in Wageningen University and Research centre, are involved in the programme.

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ABSTRACT

An experiment to determine the effect of number of stem per plant on the growth and yield of four sweet pepper varieties grown in plastic house was conducted at the Indonesian Vegetable Research Institute (IVEGRI), Lembang (1250 m asl.), West Java from April 2009 to January 2010. Two factor treatments were determined i.e. (1) number of stem per plant and (2) varieties of sweet pepper. At the number of stem per plant, three treatments were involved i.e. 2, 3 and 4 stems per plant, whereas at the varieties factor, four varieties were involved i.e. Spider, E 41.9560, Zamboni and Inspiration. The treatment combinations were arranged in a randomized complete block design with three replications. The results indicated that number of stem per plant significantly affected total yields and plants grown with 3 stems per plant gave highest total yields and yield of class > 200g compared to plants grown with 2 and 4 stems per plant. In average at the final harvest, the total yields of plants with 3 stems were 15% higher than those of plants with 2 stems and were 16% higher than those of plants with 4 stems. In class > 200 g, on average at the final harvest, the yields of plants with 3 stems were 12% higher than those of plants with 2 stems and were 17% higher than those of plants with 4 stems. In terms of variety, Spider was the highest which differed significantly with varieties E 41.9560 and Inspiration but it was not differed with Zamboni. The results of this experiment indicated that two varieties i.e. Spider and Zamboni could be suggested in the highland tropic area such Lembang, West Java. Variety E 41.9560 had the highest mean fruit weight which differed significantly with the other three varieties followed by variety Zamboni, and variety Inspiration. The lowest mean fruit weight was indicated by variety Spider. The results suggest that to obtain relatively big size fruit, E 41.9560 or Zamboni is recommended, however, in order to obtain relatively medium size fruit, Spider or Inspiration is recommended. In order to obtain optimal yields of plants grown with 4 stems per plant, research need to be conducted with a focus on system of side shoot pruning and fruit selection.

Keywords: *Capsicum annuum* var. *grossum*; Number of stem per plant; Variety

1 INTRODUCTION

The development of sweet pepper (*Capsicum annuum* var. Grosu) production in Indonesia is relatively slow. The sweet pepper has been planted initially in 1997 in Lembang area, West Java. The formal data of the production area of sweet pepper in Indonesia is not available until recently. The total production area of sweet pepper in Indonesia is estimated about 70 ha, consisted of 26 ha in Pasirlangu and 5 ha in Cigugur, Lembang (West Java), 1 ha in Garut and 1 ha in Cianjur (West Java), 15 ha in Nongkojajar (East Java), 2 ha in Bali and 20 ha in Lombok (Gunadi, 2007).

Some information of the cultivation technique such as planting system and pruning and fruit selection system in Indonesia have been obtained through the experiments conducted since 2004. Today, some sweet pepper varieties from the Netherlands have been marketed in Indonesia. However, the information of the availability of sweet pepper varieties is relatively limited in Indonesia and the sweet pepper farmers need the information of the availability of varieties adapted to their conditions. Furthermore, the information of the suitability of each variety to the planting system applied i.e. the number of stem per plant is also important in order to increase the farmers' options in selecting the sweet pepper varieties for their farms.

This experiment aims at determining the effect of number of stem per plant in four sweet pepper varieties. The results obtained from this experiment could be recommended to the sweet pepper farmers in terms of the suitability of each sweet pepper variety to the planting system i.e. number of stems per plant applied.

2 MATERIALS AND METHODS

The experiment was conducted at the Indonesian Vegetable Research Institute (IVEGRI), Lembang (1250 m asl.), West Java from April 2009 until January 2010. Plastic house with a combination of wooden poles for supporting poles and metal arches for the roof construction was used in the experiment. The plastic house has a floor surface of 12.8 x 24.0 m.

Two factor treatments were determined i.e. (1) number of stem per plant and (2) varieties of sweet pepper. In the first factor i.e. number of stem per plant, three treatments were involved i.e.

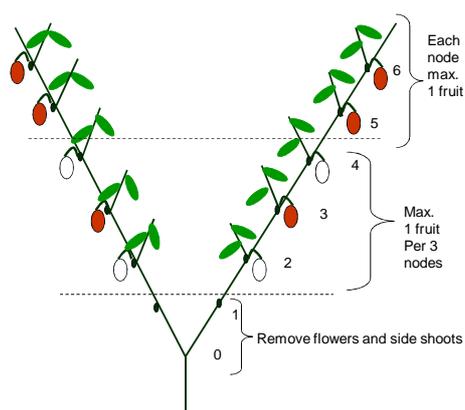
1. Two stems per plant
2. Three stems per plant
3. Four stems per plant

In the second factor i.e. varieties of sweet pepper, four varieties were involved i.e.

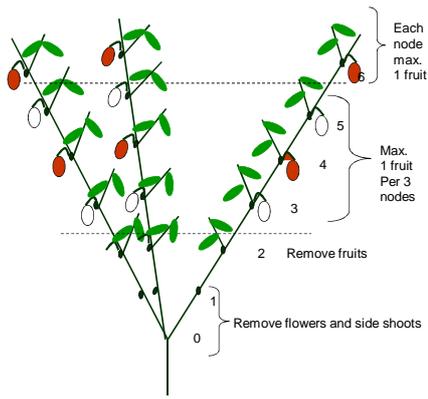
1. Spider (Enza)
2. E 41.9560 (Enza)
3. Zamboni (Rijk Zwaan)
4. Inspiration (Rijk Zwaan)

The treatment combinations were arranged in a Randomized Complete Block Design with two replications. The experimental layout of each plastic house is presented in Attachment 1.

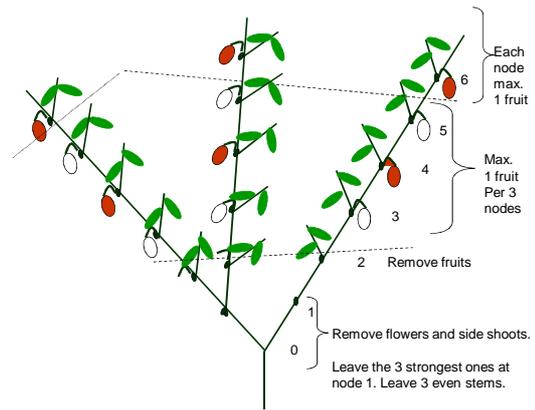
In order to have the same population density i.e. 8.4 stems per m², the following different plant or polybag spacing was applied i.e. (1) 2 stems per plant with 2 plants per bag at 1.2 x 0.4 m (2) 3 stems per plant with one plant per bag at 1.2 x 0.3 m and (3) 4 stems per plant with one plant per bag at 1.2 x 0.4 m. The technique of side shoot pruning and fruit selection for number stem per plant treatment is presented in Fig. 1.



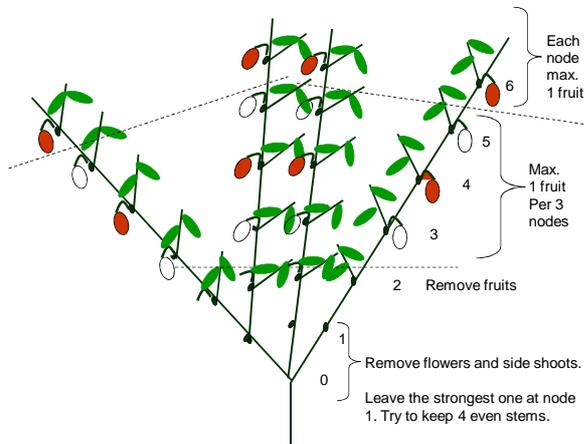
Two stems per plant



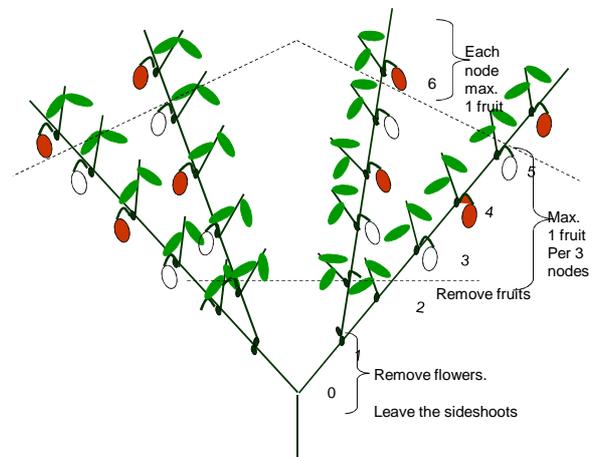
Three stems per plant with all three starting at node 0 already



Three stems per plant with two stems starting at node 0 and 1 at node 1.



Four stems per plant with three starting at node 0 already and one at node 1



Four stems per plant with two stems starting at node 0 and two stems at node 1

Figure 1. Technique of side shoot pruning and fruit selection applied in the experiment for two, three and four stems per plant treatments, Lembang, 2009

Pruning and fruit selection was done by removing all fruits and side shoots at the number zero and number one nodes. Then at node number two, three and four only one fruit, the best one, was visually selected and maintained. After that, at the subsequent nodes only one fruit was maintained.

Sweet pepper seeds were sown in sowing trays filled with carbonized rice husk on April 13, 2009 and placed for 10 to 14 days in a germination chamber (Fig. 2).



Figure 2. The sweet pepper seedlings in a sowing tray before being transplanted to a small polybags, Lembang, 2009

The sweet pepper seedlings were transplanted to the small polybag (12 cm Ø) at 10 to 14 days after sowing (Fig. 3). Transplanting to a big polybag (40 cm Ø) in the plastic house took place at five weeks after sowing (Fig. 4).



Figure 3. Transplanting the sweet pepper seedlings to small polybag (12 cm Ø) at 10 to 14 days after sowing, Lembang, 2009



Figure 4. The seedlings of five weeks after sowing were transplanted to the polybag with diameter of 40 cm in the plastic house, Lembang, 2009

The growing media used in this experiment was carbonized rice husk. Carbonized rice husk is a growing media for sweet pepper cultivation commonly used by the farmers in West Java.

For nutrition standard AB Mix produced by Buana Tani, Lembang, West Java was used. This mix is based on the Naaldwijk A0.0.0. recommendation for sweet pepper cultivation (Sonneveld, 1988). In order to have a nutrition solution with EC 2.0, the following procedure has to be carried out: dissolve pack A in 90 liter water and pack B in 90 liter water. After that, five liter of stock solution A and five liter of stock solution B has to be dissolve in 990 liter of water. Consequently 1000 l of nutrition solution with EC 2.0 is prepared. For a lower or higher EC level respectively slightly more or less then 5 liters per stock solution A and B has to be taken. The solution is adjusted with clear water or extra stock solution when after measuring the EC with an EC meter. After the desired EC level was reached, the nutrition solution was also adjusted to pH 5.8 by adding H_2NO_3 . From sowing till transplanting to the small polybag, a nutrition solution of EC 0.5 was applied, and from transplanting to the small polybag until transplanting to the big polybag, a solution of EC 1.0 was applied. One week after transplanting to the big polybag and slab, nutrition with EC 1.5 was applied and after that EC 2.0 was applied. After fruit set, a nutrition solution of EC 2.2 was applied.

In each plastic house, a fertigation frequency as many as ten times a day was applied i.e. at 7.30, 9.00, 10.30, 11.30, 12.30, 13.30, 14.30, 15.30, 17.00 and 24.00 hrs. The amount of water and nutrition applied depended on the drain measured. At the vegetative period, the desired drain level was 5 – 10%, whereas at the generative period, the desired drain level was 20 – 30%.



Figure 5. Mr. Rien Rodenburg and Mr. Ruud Maaswinkel were observing the sweet pepper plants at one month after transplanting in the greenhouse, Lembang, 2009



Figure 6. The fruits of sweet pepper were harvested per plot and directly graded into weight classes, Lembang, 2009



Figure 7. Different shapes and sizes of the four sweet pepper varieties harvested, Lembang, 2009



Figure 8. Mr. Ruud Maaswinkel observed the sweet pepper plants at six months after transplanting in the greenhouse, Lembang, 2009

3 RESULTS

3.1 Micro climate conditions in the plastic house

Data of light intensity level and temperature inside the plastic house is presented in Table 1. In this experiment, the mean light intercepted in the plastic house was 74.6% of the outdoor light level. The light intensity level in this experiment was relatively similar to that in the earlier experiment i.e. 74.3% of the outdoor light level. Similar pattern of temperatures with that of the earlier experiment was also observed in this experiment (Gunadi *et al.*, 2008). On average, the minimum and maximum temperatures inside the plastic house in this experiment were 14.7°C and 33.8°C, respectively

Table 1. Light intensity level as a percentage of the outdoor conditions and temperature inside the plastic house during the growing season, Lembang 2009

Month	Light intensity level (%)	Temperature	
		Minimum (°C)	Maximum (°C)
May	76	14.3	33.9
June	75	14.4	34.0
July	75	13.9	33.3
August	74	14.1	33.0
September	76	15.3	34.1
October	74	15.5	34.0
November	73	15.3	33.9
December	74	15.4	34.2
Mean	74.6	14.7	33.8

3.2 Crop growth

The effect of stem number per plant on the growth parameter in which indicated by the plant height during the growing season is presented in Table 2. At the initial growth until 5 Weeks After Planting (WAP), plants with 2 stems per plant planted two plants per polybag were significantly higher than those of plants with 3 stems and 4 stems per plant planted one plant per polybag. At the further growing period i.e. 7 WAP until 14 WAP, the plant height was not affected by the number of stem treatment. However, at the further growing period i.e. 16 WAP, plants with 3 stems per plant had significantly higher plants than those of plants with 2 stems and 4 stems per plant.

Tabel 2 . Effect of number of stem per plant on plant height during the growing period, Lembang 2009

No. of stem per plant	Plant height (cm) at						
	3 WAP	5 WAP	7 WAP	9 WAP	12 WAP	14 WAP	16 WAP
2 stems	15.3	29.7	51.9	75.4	99.2	110.5	117.9
3 stems	13.8	28.2	50.1	74.3	97.2	111.5	124.1
4 stems	13.6	27.9	49.1	73.9	93.8	107.0	113.0
Mean	14.2	28.6	50.4	74.5	96.7	109.7	118.4
Significance	**	*	ns	ns	ns	ns	***
CV (%)	5.4	4.1	2.7	2.4	5.2	5.0	2.9

Note: WAP = Weeks After Planting; CV = Coefficient of Variation; ns = not significant; * = significant at 5%; ** = significant at 1%; *** = significant at 0.5%

The differences in plant height of plants with 2 stems treatment with 3 stems or 4 stems treatment at the initial growing period (until 5 WAP) were presumably associated with the competition of assimilate use from the photosynthesis process of which in the plants with 2 stems, the assimilate produced would be used for only the development of two stems which differed with the plants with 3 stems or 4 stems that the assimilate produced would be use for the development of 3 stems or 4 stems. Therefore, the plants with 2 stems were always higher than the plants with 3 stems or 4 stems per plant. On the contrary, at 16 WAP the higher plants with 3 stems compared to plants with 2 stems and 4 stems per plant was presumably associated with the optimal growth obtained related to the side shoot pruning and fruit selection system applied in the 3 stems plants and therefore the plants with 3 stems were higher than the plants with 2 stems or 4 stems per plant.

Data of plant height of the four sweet pepper varieties evaluated in this experiment is presented in Table 3. During the growing period, plant height were always differed between the four varieties evaluated, however the differences were not consistent during the growing period. At the initial growing period until 9 WAP, varieties Spider and Zamboni had always higher plants compared to the other two varieties, however at the later stage of growing period, variety Inspiration had the highest plants compared to the other three varieties. During the growing period, the plants of variety E 41.9560 were lowest compared to the other varieties. The differences in plant height between varieties during the growing period were presumably associated with the characteristics of each variety evaluated in this experiment.

Table 3. Plant height of four sweet pepper varieties during the growing season, Lembang 2009

Variety	Plant height (cm) at						
	3 WAP	5 WAP	7 WAP	9 WAP	12 WAP	14 WAP	16 WAP
Spider	15.3	30.6	52.7	77.5	101.8	113.5	119.1
E 41.9560	12.6	27.7	47.6	67.9	87.4	98.5	110.0
Zamboni	16.1	29.9	52.7	77.9	98.3	112.9	121.7
Inspiration	12.6	26.3	48.5	74.9	99.4	113.8	122.6
Mean	14.2	28.6	50.4	74.5	96.7	109.7	118.4
Significance	***	***	***	***	**	**	***
CV (%)	5.4	4.1	2.7	2.4	5.2	5.0	2.9

Note: WAP = Weeks After Planting; CV = Coefficient of Variation; ns = not significant; * = significant at 5%; ** = significant at 1%; *** = significant at 0.5%

The effect of number of stem per plant on the development of plant height of each variety in this experiment are presented in Figures 9, 10, 11 and 11. In this experiment, all varieties had similar respond to the number of stem treatments. At the initial stage of the growing period, the plants with 2 stems were higher until July 29 (9 WAP) compared the plants with 3 or 4 stems. However, at the further stage of growing period, in all varieties, the plants with 3 stems were higher than the plants with other number of stem treatments.

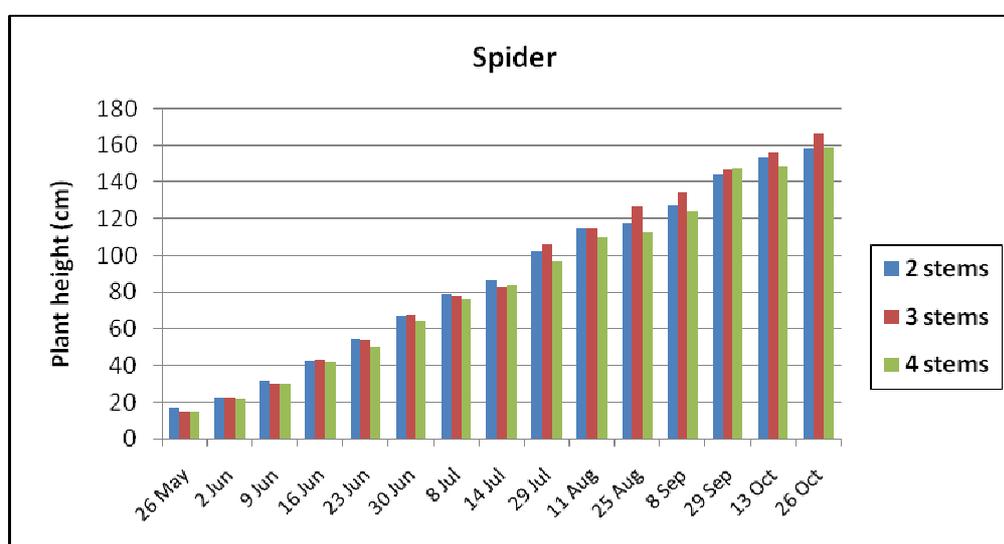


Fig. 9. Effect of number of stem per plant on the development of plant height of variety Spider during the growing period, Lembang 2009

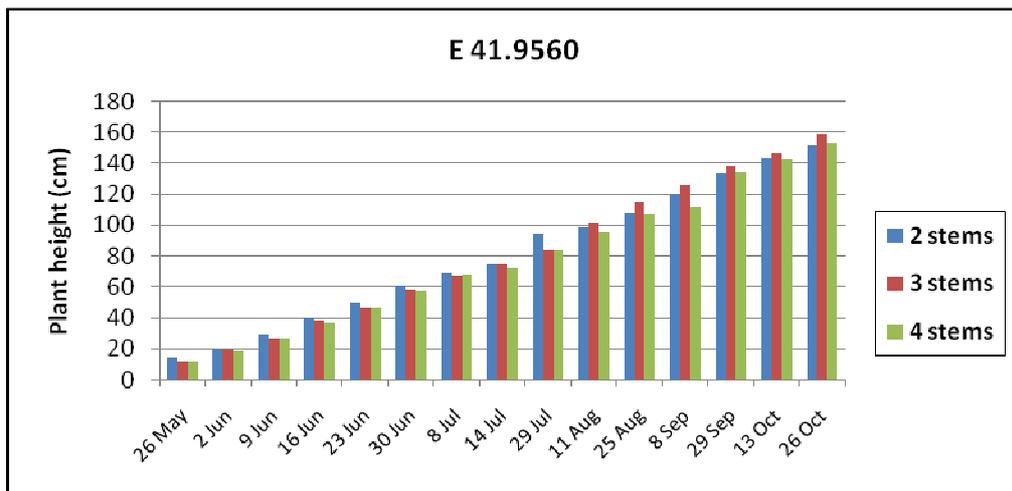


Fig. 10. Effect of number of stem per plant on the development of plant height of variety E 41.9560 during the growing period, Lembang 2009

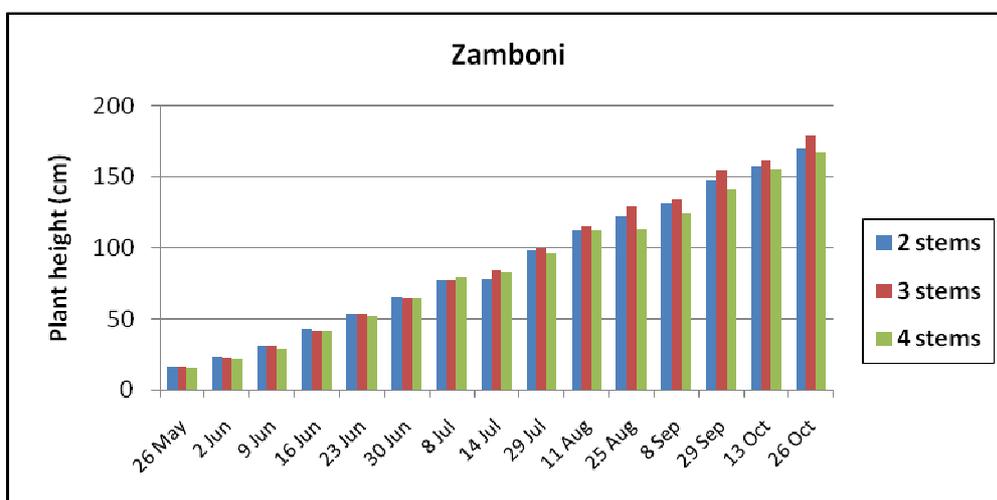


Fig. 11. Effect of number of stem per plant on the development of plant height of variety Zamboni during the growing period, Lembang 2009

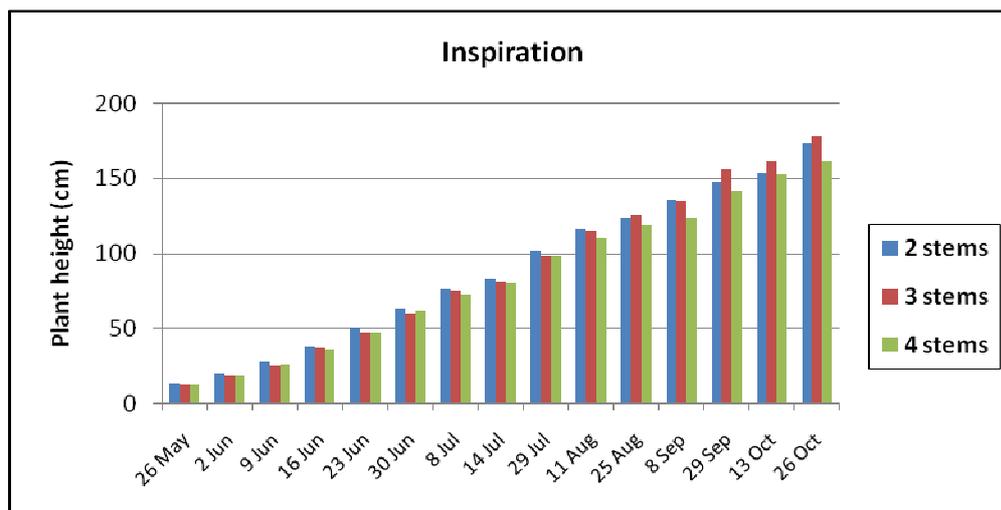


Fig. 12. Effect of number of stem per plant on the development of plant height of variety Inspiration during the growing period, Lembang 2009

3.3 Yield component

The effect of number of stem per plant on total yields and yield of sweet pepper in each class category is presented in Table 5. In this experiment, the highest total yields were obtained by plants with 3 stems per plant which differed significantly with the plants with 2 and 4 stems per plant. The significant differences in total yields were initially indicated on October 1 and continued until the final harvest on January 28. On average at the final harvest, the total yields of plants with 3 stems were 15% higher than those of plants with 2 stems and were 16% higher than those of plants with 4 stems (Figure 13).

Table 5. Effect of number of stem per plant on the yields sweet pepper (kg.m⁻²) in each class category, Lembang 2009

No. of stem per plant	Yields (kg.m ⁻²)				Mean fruit weight (g)
	Total	> 200 g	100-200 g	< 100 g	
2 stems	14.31 b	12.92 ab	1.25 b	0.0083	231 a
3 stems	16.41 a	14.42 a	1.75 ab	0.0093	227 a
4 stems	14.19 b	12.29 b	1.82 a	0.0069	222 b
Mean	14.97	13.21	1.61	0.0082	227
Significance	*	*	*	ns	*

Note: ns = not significant; * = significant at 5%

As the observation in total yields, the highest yield of fruit > 200 g was obtained by plants with 3 stems per plant which differed significantly with those of plants with 2 or 4 stems per plant. On average at the final harvest, the

yields of fruit > 200 g of plants with 3 stems were 12% higher than those of plants with 2 stems and were 17% higher than those of plants with 4 stems. In class 100-200 g, the plants with 4 stems per plant had highest yield followed by the plants with 3 stems and 2 stems per plant. At the lowest class i.e. class < 100 g, the effect of number of stem per plant treatment was not significant on the yields.

In terms of mean fruit weight at the final harvest, differences were found between treatments (Table 5). The mean fruit weight derived from plants with 2 stems per plant (231 g) was higher than that of plants with 3 stems (227 g) and 4 stems per plant (222 g), however the differences were only significantly with that of plants with 4 stems per plant.

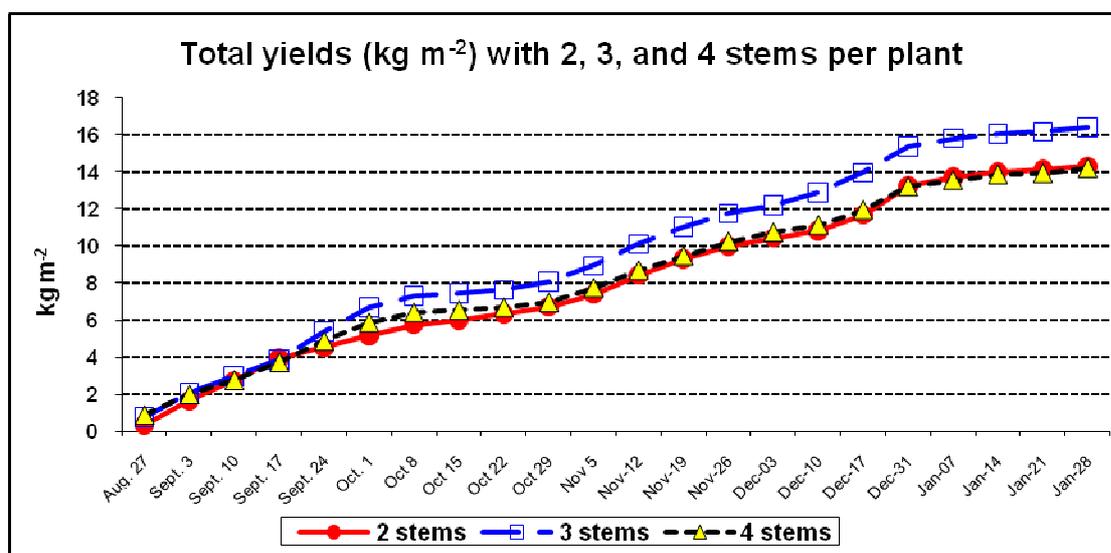


Fig. 13. The development of total yields of plants with 2, 3 and 4 stems per plant, Lembang 2009

The yield component of four sweet pepper varieties in each class category is presented in Table 6. In terms of total yields, variety Spider was highest which differed significantly with varieties E 41.9560 and Inspiration but it was not differed with Zamboni. In class >200 g, however, the yield was highest in E 41.9560 which differed significantly with Spider and Inspiration but it was not differed with Zamboni. At the lower class i.e. 100-200 g, the highest yield was indicated by variety Spider which differed significantly with the other three varieties. The yields in class < 100 g were not significantly differed between varieties.

Table 6. Yield component of four sweet pepper varieties (kg.m⁻²) in each class category, Lembang 2009

Variety	Yields (kg.m ⁻²)				Mean fruit weight (g)
	Total	> 200 g	100-200 g	< 100 g	
Spider	15.57 a	12.81 b	2.68 a	0.0046	206 d
E 41.9560	14.72 b	13.70 a	0.93 b.	0.0099	250 a
Zamboni	15.07 ab	13.59 ab	1.24 b	0.0048	231 b
Inspiration	14.51 b.	12.76 b	1.57 b	0.0133	220 c
Mean	14.97	13.21	1.61	0.0082	227
Significance	*	*	*	ns	***

Note: ns = not significant; * = significant at 5%; *** = significant at 0.1%

In terms of mean fruit weight, at the final harvest the highest mean fruit weight was indicated by variety E 41.9560 which differed significantly with the other varieties, followed by varieties Zamboni and Inspiration (Table 6). The lowest mean fruit weight was indicated by variety Spider.

The development of total yields in plants with 2, 3 and 4 stems per plants in each sweet pepper variety are presented in Figures 14, 15, 16 and 17. The four sweet pepper varieties evaluated i.e. Spider, E 41.9560, Zamboni and Inspiration in this experiment indicated the same development pattern in the total yields in which at the beginning of harvest until weeks 16 (17 September), the total yields were not significantly differed between all the three treatments, however, after weeks 17 (24 September), plants with 3 stems in all varieties indicated the better development of total yields compared to plants with 2 or 4 stems per plant. The results in this experiment suggest that in order to have a higher yield, the use of 3 stems per plant system is suggested in all four sweet pepper varieties evaluated with the stem population of 8.4 stems per m² as also used in this experiment.

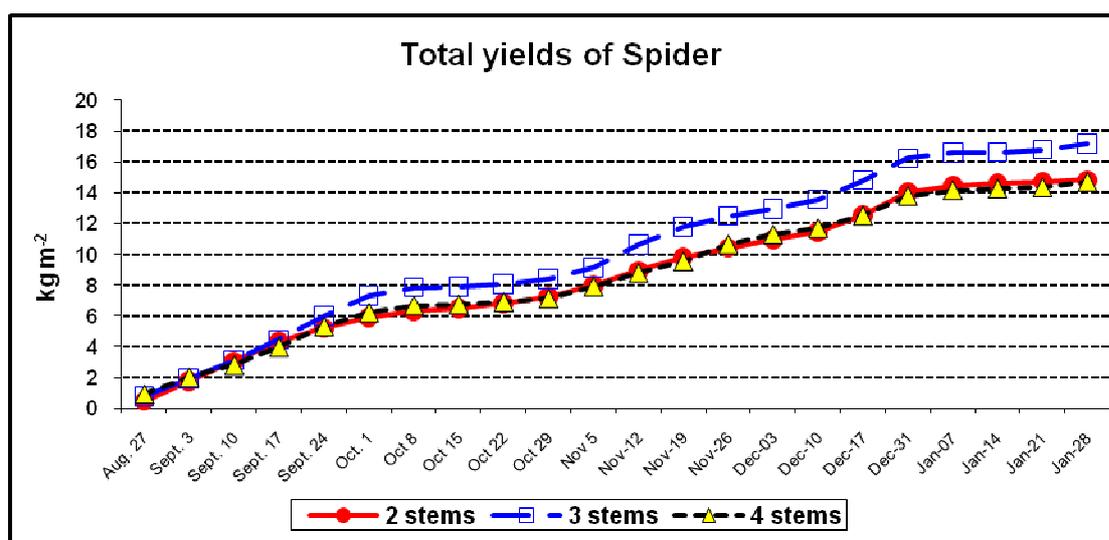


Fig. 14. The development of total yields of variety Spider with 2, 3 and 4 stems per plant, Lembang 2009

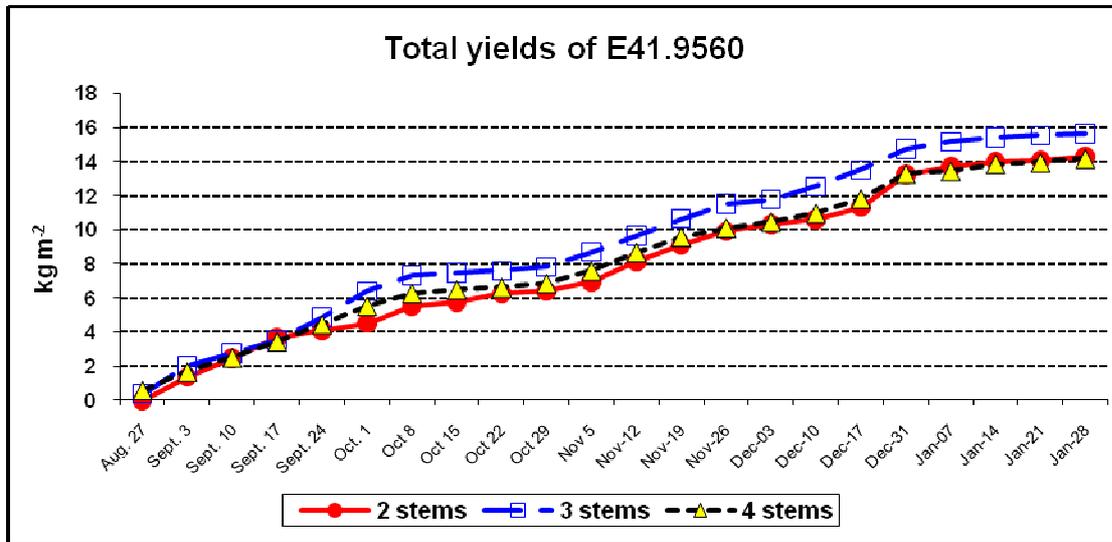


Fig. 15. The development of total yields of variety E 41.9560 with 2, 3 and 4 stems per plant, Lembang 2009

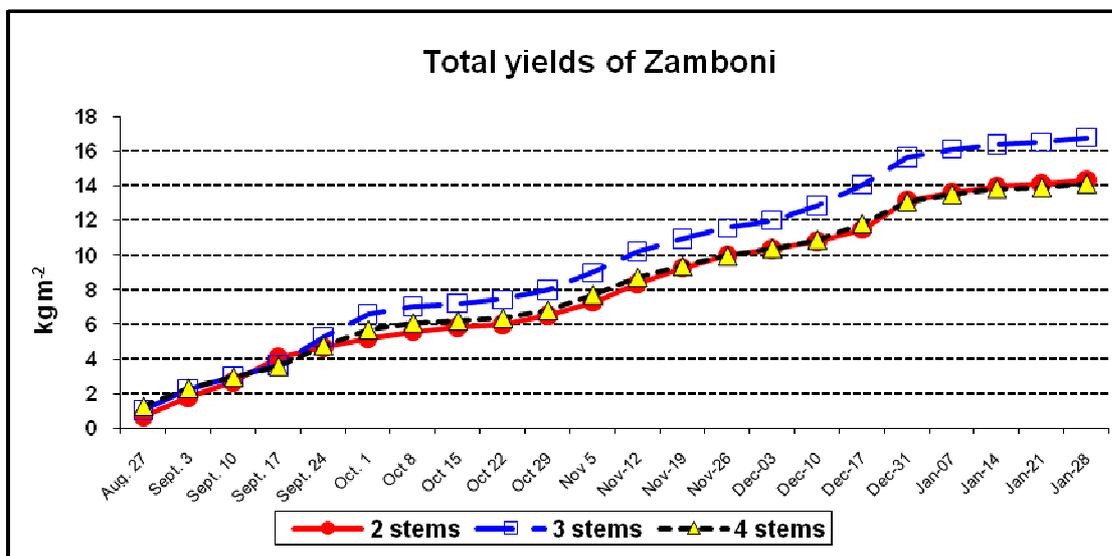


Fig. 16. The development of total yields of variety Zamboni with 2, 3 and 4 stems per plant, Lembang 2009

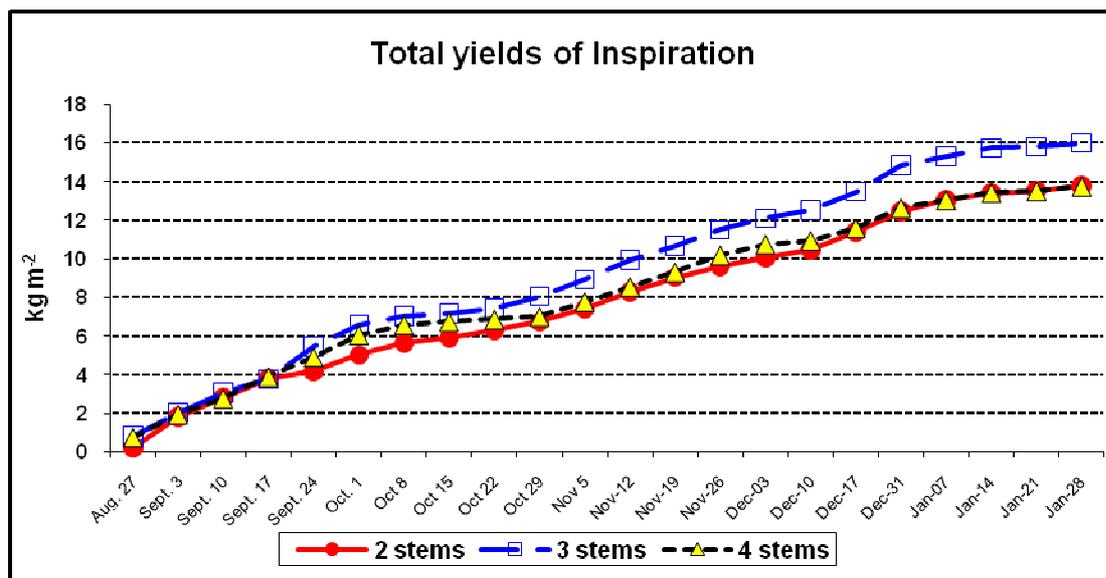


Fig. 17. The development of total yields of variety Inspiration with 2, 3 and 4 stems per plant, Lembang 2009

The effect of number of stem per plant on number of fruits in each class category is presented in Table 7. In this experiment, as also indicated on the total yields, the highest total number of fruits was also found in plants with 3 stems which differed significantly with that of plants with 2 stems but not with 4 stems per plant. On average, the total number of fruit in plants with 3 stems was 17% and 14% higher than those of plants with 2 stems and 4 stems, respectively. As indicated in the total number of fruit, the number of fruit in class > 200 g was also highest in plants with 3 stems which differed significantly with that of plants with 4 stems but not with 2 stems per plant. The plants with 3 stems per plant gave 13% and 16% higher number of fruit in class > 200 g compared to those of plants with 2 stems and 4 stems, respectively. In the lower class i.e. fruit 100-200 g, the effect of number of stem per plant was not found. The mean number of fruit in class 100-200 g was 9.8 fruits per m².

Table 7. Effect of number of stem per plant on the number of fruit in each class category, Lembang 2009

No. of stem per plant	No. of fruit (#.m ⁻²)		
	Total	> 200 g	100-200 g
2 stems	62.4 b	54.0 ab	7.7
3 stems	73.0 a	61.0 a	10.7
4 stems	64.2 ab	52.6 b	11.1
Mean	66.5	55.9	9.8
Significance	*	*	ns

Note: ns = not significant; * = significant at 5%

As also indicated in the total yields (Figures 14, 15, 16 and 17), in terms of total number of fruit, the four sweet pepper varieties indicated similar pattern as affected by the number of stem per plant treatments (Figure 18). The plants with 3 stems per plant in all varieties gave higher total number of fruit compared to plants with 2 or 4 stems per plant. The results in this experiment also suggest that in order to have a higher total number of fruit, it is recommended to use the 3 stems per plant system.

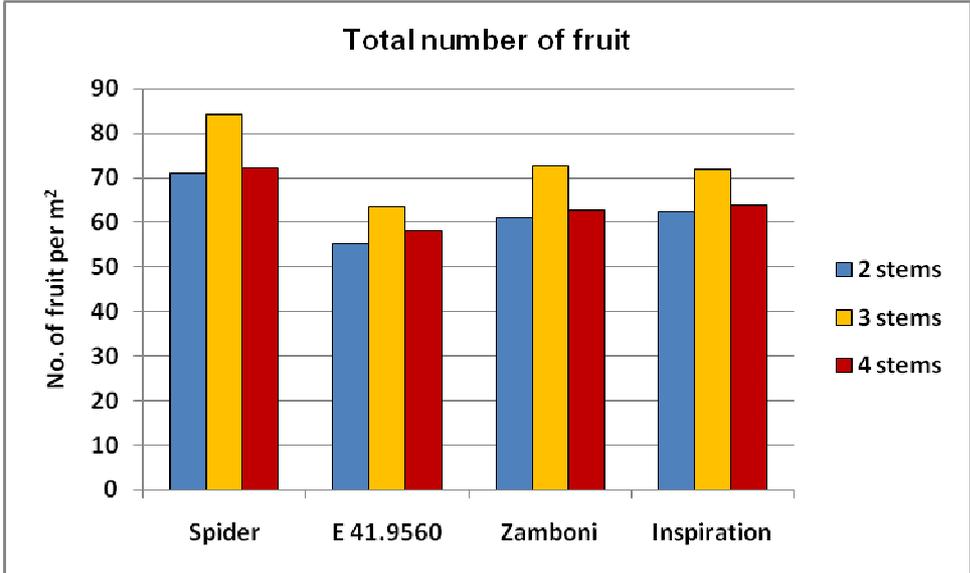


Fig. 18. Effect of number of stem per plant on the total number of fruit in each sweet pepper variety, Lembang 2009

4 DISCUSSION

The aim of the present experiment was at determining the effect of number of stem per plant in four sweet pepper varieties. The information of the availability of sweet pepper varieties is relatively limited in Indonesia and therefore the sweet pepper farmers need the information of the availability of varieties adapted to their conditions. Furthermore, the information of the suitability of each variety to the planting system i.e. the number of stem per plant obtained from this experiment is also important in order to increase their options for sweet pepper varieties for their farms.

In this experiment, the effect of number of stem per plant significantly affected the yields of sweet pepper (Table 5). The highest total yields were obtained by plants with 3 stems per plant which differed significantly with the plants with 2 and 4 stems per plant. The significant differences in total yields were initially indicated on October 1 and continued until the final harvest on January 28. On average at the final harvest, the total yields of plants with 3 stems were 15% higher than those of plants with 2 stems and were 16% higher than those of plants with 4 stems (Figure 13). As the observation in total yields, the highest yield of fruit > 200 g was obtained by plants with 3 stems per plant which differed significantly with those of plants with 2 or 4 stems per plant. On average at the final harvest, the yields of fruit > 200 g of plants with 3 stems were 12% higher than those of plants with 2 stems and were 17% higher than those of plants with 4 stems. The results of the experiment found here were similar to the results of the experiment conducted in 2007, in which the total yields and the yield of fruits > 200 g were significantly higher with plants with 3 stems per plant compared to those of plants with 2 stems per plant (Gunadi *et al.* 2007). The higher yields of plants with 3 stems per plant compared to those of plants with 2 stems per plant was presumably associated with the difference system of side shoot pruning and fruit selection applied in each treatment especially the fruit selection at early nodes. In plants with 3 stems, the side shoot and flowers/fruits at nodes number 0, number 1 and number 2 were removed, then at nodes number 3, number 4 and number 5 only one fruit kept in each stem, after that at each node only one fruit was kept, while in plants with 2 stems, the side shoot and flowers/fruits at nodes number 0 and number 1 were removed, then at nodes number 2, number 3 and number 4 only one fruit kept in each stem, after that at each node only one fruit was kept (Figure 1). In the 3 stems system, the sweet pepper plants were initially led to develop the plants with strong stems first before the plants set the fruits, while in the 2 stems system, the plants were faster set the fruits. The better development of plants with 3 stems in this experiment allowed also the higher yields compared to those of plants with 2 stems. In sweet pepper, fruit setting is positively correlated with the source strength and is negatively correlated with the sink strength and therefore positively correlated with source:sink ratio (Heuvelink *et al.*, 2002; Marcelis *et al.* 2004; Wubs *et al.* 2007). The variation in weekly production in the sweet pepper plants was also related to the plant fruit load manipulation (Abdel-Mawgoud *et al.*, 2008).

In terms of the use of seed, the 3 stems system was more efficient compared to the 2 stems system. In this experiment, in order to have the same stems population i.e. 8.4 stems per m², the 3 stems system, only plant was planted in one polybag with a planting distance of 1.2 m x 0.3 m, while in the 2 stems system, two plants were planted in one polybag with a planting distance of 1.2 m x 0.4 m. Therefore the 2 stems system needed 2 seeds per polybag and the 3 stems system needed only 1 seed per polybag. The 3 stems system only used 2/3 (two third) of the 2 stems system. In the Netherlands, the growers in general are also use the 3 stems system for the sweet pepper grown in the glass house (Rodenburg, 2006, *personal communication*). In addition, Dasgan and Abak (2003) in their experiment found that in order to have a higher yield, 2 stems per plant was recommended for sweet pepper cultivation, however if the price of seed is expensive, 3 stems per plant is more economic for the sweet pepper cultivation.

The plants with 4 stems per plant in this experiment gave lower total yields and the yield of fruit > 200 g compared to those of plants with 3 stems per plant. The lower yields of plants with 4 stems compared to plants with 3 stems were presumably associated with source:sink ratio as explained earlier. In this experiment, the side shoot pruning and fruit selection system of the 3 stems was similar to that of the 4 stems (Figure 1). The differences in yields between the 3 stems and the 4 stems found here, were presumably associated with the competition on the use of assimilate from the photosynthesis process. In the 3 stems plants, the assimilate from the photosynthesis process would only be used for the 3 stems kept while in the 4 stems plants, the assimilate from the photosynthesis process would be used for the 4 stems kept and therefore the yields of plants with 3 stems were higher than those of plants with 4 stems. In order to obtain optimal yields of plants grown with 4 stems per plant, research need to be conducted with a focus on system of side shoot pruning and fruit selection. In general, the sweet pepper cultivated in the protected cultivation system is indeterminate type. The plants of indeterminate type need special

maintenance especially in the pruning stage including the side shoot pruning and fruit selection. The plant balance between energy produced and its use for plant growth and fruit setting as well as fruit development is an important factor in determining yields of sweet pepper (Verberne, 2006; Brakeboer, 2007).

The four sweet pepper varieties evaluated i.e. Spider, E 41.9560, Zamboni and Inspiration in this experiment indicated the same development pattern in the total yields in which at the beginning of harvest until weeks 16 (17 September), the total yields were not significantly differed between all the three treatments, however, after weeks 17 (24 September), plants with 3 stems in all varieties indicated the better development of total yields compared to plants with 2 or 4 stems per plant (Figures 14, 15, 16 and 17). The increase of total yields obtained with 3 stems system in varieties Spider, E 41.9560, Zamboni and Inspiration were 16, 9, 17 and 16%, respectively compared to those with 2 stems system, and were 17, 10, 19 and 16%, respectively compared to those with 4 stems system. The results in this experiment suggest that in order to have a higher yield, the use of 3 stems per plant system is suggested in all four sweet pepper varieties evaluated with the stem population of 8.4 stems per m². In this experiment, the 3 stems system was the planting system of one plant planted in one polybag with the planting distance of 1.2 m x 0.3 m and this system was found to be the suitable to obtain the optimum yield for sweet pepper grown under plastic house condition in the highland tropic in Indonesia (Gunadi *et al.* 2005).

In terms of variety, Spider was highest which differed significantly with varieties E 41.9560 and Inspiration but it was not differed with Zamboni. In class >200 g, however, the yield was highest in E 41.9560 which differed significantly with Spider and Inspiration but it was not differed with Zamboni (Table 6). The results of this experiment indicated that two varieties i.e. Spider and Zamboni could be suggested in the highland tropic area such Lembang, West Java. However, another factor that should be considered also in the sweet pepper cultivation is the mean fruit weight. Variety E 41.9560 had highest mean fruit weight which differed significantly with the other three varieties followed by variety Zamboni, and variety Inspiration. The lowest mean fruit weight was indicated by variety Spider. The results of this experiment suggest that in order to have relatively big fruits, varieties E 41.9560 or Zamboni should be planted, however in order to have relatively small fruits, varieties Spider or Inspiration should be planted.

5 CONCLUSIONS

Significant effect of number of stem per plant was found and plants with 3 stems gave the highest total yields and yield of fruit > 200 g compared to plants with 2 stems or 4 stems. In average at the final harvest, the total yields of plants with 3 stems were 15% higher than those of plants with 2 stems and were 16% higher than those of plants with 4 stems. In class > 200 g, on average at the final harvest, the yields of plants with 3 stems were 12% higher than those of plants with 2 stems and were 17% higher than those of plants with 4 stems.

In terms of variety, Spider was the highest which differed significantly with varieties E 41.9560 and Inspiration but it was not differed with Zamboni. The results of this experiment indicated that two varieties i.e. Spider and Zamboni could be suggested in the highland tropic area such Lembang, West Java.

Variety E 41.9560 had the highest mean fruit weight which differed significantly with the other three varieties followed by variety Zamboni, and variety Inspiration. The lowest mean fruit weight was indicated by variety Spider. Mean fruit weight of E 41.9560, Zamboni, Inspiration and Spider were 250, 231, 220 and 205 g, respectively. The results suggest that to obtain relatively big size fruit, E 41.9560 or Zamboni is recommended, however, in order to obtain relatively medium size fruit, Spider or Inspiration is recommended.

In order to obtain optimal yields of plants grown with 4 stems per plant, research need to be conducted with a focus on system of side shoot pruning and fruit selection.

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