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Yield and Yield Components of Pepper (*Capsicum Annuum* L.) as Influenced by Stage and Intensity of Reproductive Organs Pruning at Humbo, Southern Ethiopia

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Abstract
Field experiment was conducted on farmer's field from 2009 to 2010 at Humbo, Southern Ethiopia, to assess the effects of stage and intensity of reproductive organs pruning on yield and yield component of pepper. Four levels of pruning (control, one-reproductive organ, two-reproductive organs and three-reproductive organs) and three stages of pruning (bud, anthesis and fruit set), were arranged in factorial combination in Randomized Complete Block Design with three replications. Pepper cultivar called 'Marekofana' was used. The interaction effect of three- reproductive organs pruned treatment with fruit set stage gave the highest for total leaf area of pepper and the least was obtained from the control. Three- reproductive organs pruning improved fresh and dry weight of individual fruits per plant and seed dry weight per fruit. The highest total dry weight of fruit per plant was from the control plants and the least being at three- reproductive organs pruning. The highest vegetative dry weight of the plant and total dry weight of the plant were obtained three- reproductive organs were pruned at anthesis stage and the lowest were obtained from the control respectively. The highest and the lowest seed number per fruit recorded two- reproductive organs were pruned at bud stage and from the control treatment, respectively. The highest early yield per plant was obtained from the control and significant reduction was observed with reproductive organs pruning. The highest and the lowest marketable fruit yield per plant were obtained from one-reproductive organ and the three- reproductive organs pruned treatment, respectively. On the contrary, the highest and the lowest unmarketable fruit yield per plant were obtained from the three- reproductive organs and one- reproductive organ pruned treatment, respectively. The highest marketable and unmarketable fruit number per plant were obtained from the control while the lowest marketable and unmarketable fruit number per plant were obtained from the three- reproductive organs pruned treatment. The highest total fruit yield per plant and total fruit yield per hectare were obtained from one- reproductive organ pruned treatment and the lowest total fruit yield per plant and per hectare were obtained from the three- reproductive organs pruned treatment.
Keywords: Stage, intensity, reproductive organ, pruning, pepper

INTRODUCTION

Pepper (*Capsicum annuum* L.) is an economically and traditionally important crop in Ethiopia. It is a major spice and vegetable crop produced by the majority of farmers in .Pepper is warm season crop which is annual in temperate regions, but can produce continuous growth in tropical areas. The continuous growth of the plant in tropics increase the number of fruit per plants and which increases the potential for competition between fruits and the consequent reduction in fruit size (Van Ravestijin and molhoek, 1978). Pruning of some of the flowers or fruits from crops like tomato and pepper results in assimilate re-distribution to the remaining fruits and increase their size. However, the extent of re-distribution of assimilates to the remaining fruits appears to depend mainly on the sink-strength of fruit which varies with age of fruit and on the transport path way (Kinet and Peet, 1997).

Therefore, studies on a non chemical method of reproductive organs pruning had significantly importance as the pepper cultivar 'Marekofana' is widely grown in the different parts of the country as fresh market and dried pods. Ethiopians have strong attachments to dark red pepper, which has high value principally for its high pungency. The fine powdered pungent product is an indispensable flavoring and coloring ingredient in the common traditional sauce 'wot' where as the green pod is consumed as vegetable with other food items. There is a general belief among Ethiopians that a person who frequently consumes hot pepper has resistance to various diseases'. Besides, it has significant economic importance in the country, vital role as a means of income generation to the farmers and immense potential in the country for expansion and for export markets. Hence, there is no recommendation when and at what intensity reproductive organs pruning should be effected to regulate fruit size and ultimately to influence fruit yield. Therefore, assessing the effect of stage and intensity of reproductive organs pruning on yield and yield component of pepper is the objective of the study presented in this paper.

MATERIALS AND METHODS

Description of the Study Site

The study was conducted on farmer field at Humbo woreda of Wolaita Zone in 2009/2010 'belg' growing season. Humbo is located in the Southern Nation Nationalities and Peoples Regional State. It is located at 6°40'46"N latitude and 37°46'56"E longitude at an altitude of 1450 m.a.s.l and the area has bimodal rainfall distribution with mean annual rainfall of 500 mm. Seventy percent of the woreda has hot to warm climate with mean minimum and maximum air temperature of 24°C and 32°C, respectively. The soil is Nitisol, reddish brown in color and classified as sandy loam in texture (Gebre, 2007).

Planting material

Pepper (*Capsicum annuum* L.) cultivar 'Mareko Fana' was used for the study. As Peppers show a lot of variability, two main branches were retained per plant and the other ones were pruned just above its first leaf. In this way, plants with two main branches were formed.

Treatments and experimental design

The experiment was laid in a Randomized Complete Block Design (RCBD) in a 4x3 factorial arrangement with three replications. There were a total of twelve treatment combinations; four pruning intensities and three stages of pruning. The gross area of each plot was 10.5 m^2, with 3 m length and 3.5 m width. The spacing between plots and adjacent replication were 1 m and 1.5 m, respectively. There was a total of 634.5 m^2 area for experimental site.

Pruning intensities: Treatment 1: no reproductive organs pruned (control), Treatment 2: the first reproductive organ pruned, Treatment 3: the first two reproductive organs pruned and Treatment 4: the first three reproductive organs pruned

Stage of pruning: At bud stage, at anthesis of the first flower and at fruit set (when the first fruit was attained 2 mm in diameter).

Cultural Practices

Land preparation for nursery bed and main field were done in 2009 and 2010, respectively, using oxen and human labor. Seedlings of pepper were sown on November 1, 2009 on well prepared seed beds of 1 m width and 5 m length at spacing of 15 cm between rows. After sowing, the beds were covered with hay mulch until emergence. In the nursery 10 kg P_2O_5 ha^{-1} in the form of DAP (46% P_2O_5 and 18% N) at sowing and 10 kg N ha^{-1} in the form of urea (46% N) was applied after thinning. Well established seedlings (standard seedlings) at 3 to 4 leaves stage, were transplanted in January 29, 2010 to experimental field on ridges in five rows per plot at spacing of 70 x30 cm with 10 seedlings per row to obtain 50 plants per plot. The recommended fertilizer, 100 kg DAP ha^{-1} was applied once at transplanting and 100 kg urea ha^{-1} was applied 50% at transplanting and the remaining 50% at the onset of flowering. The fertilizers applied during transplanting were applied in a band form on the ridges and incorporated in the soil to facilitate nutrient up take by the plants. The crop was cultivated under supplementary irrigation conditions. No major disease and pest incidences were encountered, but weeding and other necessary cultural practices were employed uniformly to all treatments during all the stages of crop growth.

Data Collected

Data were collected on fresh weight of individual fruit per plant , Dry weight of individual fruit per plant , Seed dry weight per fruit ,total dry weight of fruit per plant , Vegetative dry weight of the plant , total dry weight of the plant, Seeds number per fruit, early yield per plant , marketable fruit yield per plant , unmarketable fruit yield per plant , marketable fruit number per plant, unmarketable fruit number per plant, total fruit yield per plant ,total fruit yield per hectare and total leaf area: The area of each leaf was calculated using a formula developed by (Erik *et al*., 2004) as: LA= 0.69 x LxW: Where: LA= Leaf area, L=Leaf length, W= Leaf width. Data were taken from five randomly selected plants in the three central rows and fruits were harvested at the mature red stage.

Data Analysis

The data were subjected to analysis of variance using SAS statistical software (SAS Version 6.12, 1997). Means were compared using the Least Significant Difference (LSD) test at 5% or 1% probability levels.

RESULTS AND DISCUSSION

Fresh and dry weight of individual fruit per plant and seed dry weight per fruit

Fresh and dry weights of individual fruit per plant and seed dry weight per fruit were not significantly ($P < 0.05$) affected by the stage of pruning. However, there was highly significant ($P < 0.01$) increase in fresh and dry weight of individual fruit per plant and seed dry weight per plant in response to increased intensity of pruning (Table 1) .Three-reproductive organs pruning improved fresh and dry weight of individual fruits per plant and seed dry weight by about 109.64%, 52.8% and 65% respectively, compared to the unpruned treatment. The increase in fresh and dry fruit weight of individual fruit per plant and seed dry weight per fruit in response to the pruning treatment could be due to the reduction of inter-fruit competition. Similarly, Ali and Kelly (1992) found

a similar increase in the size of sweet pepper fruit as the result of removal of flower buds, flowers and set fruits on the first three flowering nodes.

Total dry weight of fruit per plant

Total dry weight of fruit per plant was not significantly ($P < 0.05$) affected by the stage of pruning but it was highly significantly ($P < 0.01$) influenced by intensity of pruning (Table 1). The highest total dry weight of fruit per plant (54.11 g) was from the control plants and as the intensity of pruning increases it had significantly decreased the total fruit dry weight and the least value (38.72 g) being at three-reproductive organs pruning. This could be due to reduction in dry matter accumulation in the fruit and a decrease fruit number that was not significantly compensated by individual fruit size improvement in response to pruning. The result was in agreement with the observations of Guinn and Mauney (1980), where profound increase in source: sink ratio due to intensive pruning reduced dry matter production (source activity). `

Total leaf area

Total leaf area of pepper was significantly ($P<0.01$) affected by the interaction effects of stage and intensity of pruning (Table 2). The highest total leaf area (6945.88 cm^2) was obtained three-reproductive organs were pruned at fruit set stage. This may be because fruits are the major sink of assimilates and a reduction in fruit load could favor the distribution of assimilates to the vegetative parts of the plant. Similarly, Ehret *et al*. (1993) observed higher foliage: fruit ratio when some fruits were pruned from tomato plants as compared to the non pruned ones

Vegetative dry weight of the plant

Vegetative dry weight of the plant was highly significantly ($P < 0.01$) affected by the interaction effect of stage and intensity of fruit pruning (Table 2). The highest vegetative dry weight of the plant (71.87g) was obtained three-reproductive organs were removed at anthesis stage and the lowest (56.9g) was obtained from the control. Fruit pruning increased dry weight of vegetative parts (leaves and stems) and this could be attributed to reduced assimilate utilization for fruit development and the diversion of more assimilate to the vegetative parts. In agreement with the current finding, Heuvelink and Buiskool (1995) stated that fruit and truss pruning led to higher average fruit weight, heavier stems and leaves and thicker leaves in tomato

Total dry weight of the plant

Total dry weight of the plant was highly significantly ($P<0.01$) affected by the interaction effects of stage and intensity of fruit pruning (Table 2). The highest total dry weight (110.59 g) of the plant was obtained three-reproductive organs were removed at anthesis stage and the lowest (102.18 g) was obtained from the control. This could be attributed to reduced assimilate utilization for fruit development and the diversion of more assimilate to the vegetative parts.Similarly, Marcelis (1991) stated that fruit pruning favors assimilate distribution towards the vegetative plant parts including the leaves.

Seed number per fruit

Seed number per fruit was highly significantly ($P<0.01$) affected by the interaction effects of stage and intensity of fruit pruning (Table 2). The highest mean seed number per fruit (148.21) was recorded two-fruit were pruned at bud stage while the lowest seed number per fruit (100.15) was obtained from the control. Similarly, Zhiyuang *et al*. (1982) indicated that removal of the two earliest flowers of capsicum plants increased the seed content of the remaining fruit. Even though the mechanisms that brought about this phenomenon are not clear yet, this could be one of the causes for an increase in fruit size when older fruit are removed from plants (Tsedal, 2004).

Early yield per plant

Early yield per plant was not significantly ($P < 0.05$) affected by the stage of pruning however, it was highly significantly ($P<0.01$) influenced by intensity of pruning (Table 1). The highest early yield per plant (110 g) was obtained from the control and significant reduction was observed with reproductive organs pruning although one-, two- and three-reproductive organs pruning gave comparable yield. This is because the unprunned reproductive organs on the control plants produced the first fruit which usually matures first. In agreement with the current finding Tsedal (2004) observed significantly higher early yield per plant in the control than pruned plants.

Marketable and unmarketable fruit yield per plant

Marketable and unmarketable fruit yields per plant were not significantly ($P < 0.05$) affected by the stage of pruning. However, fruit pruning highly significantly ($P<0.01$) decreased marketable fruit yield per plant while increasing the unmarketable component (Table 3). The highest marketable fruit yield per plant (170.63 g) was obtained from one-reproductive organ pruned treatment, which was statistically at par with the control while the three-reproductive organs pruned treatment gave the lowest marketable yield (151.3 g) per plant which was also statistically at par with the two-reproductive organs pruned treatment. On the contrary, the highest unmarketable fruit yield (8.24 g) per plant was obtained from three-reproductive organs pruned treatment which was statistically at par with the two-reproductive organs pruned treatment, while the control treatment gave the lowest unmarketable fruit yield (4.49 g) per plant which was also statistically at par with the one-reproductive organ pruned treatment. The lower marketable yield in two-, three-reproductive organs pruned plants may be attributed to significant reduction in marketable number of fruit per plant and the loss of potential yield due to

pruning that could not be fully compensated by mere increase of an individual fruit size in response to the fruit pruning. The increase in unmarketable fruit yield per plant in two- and three-reproductive organs pruned treatments could be associated with the diversion of more assimilates to the remaining fruits that might have caused physiological disorders. In agreement with the current finding, Dorais and Papadopoulos (2001) indicated that over pruning can cause yield loss and increase physiological disorder like fruit cracking, discolored and diseased which are associated with the rapid movement of water and sugars towards the fruit when cuticle elasticity and resistance are weak during ripening.

Marketable and unmarketable fruit number per plant

Marketable and unmarketable fruit numbers per plant were not significantly ($P < 0.05$) affected by the stage of pruning however, both were highly significantly ($P < 0.01$) decreased by intensity of pruning (Table 3). The highest marketable (36.44) and unmarketable (3.76) fruit number per plant were obtained from the control while the lowest marketable (16.4) and unmarketable (1.04) fruit number per plant were obtained from the three-reproductive organs pruned treatment. The observed high percentage of unmarketable fruit per plant in the control treatment may be due to the presence of naturally many fruits and high competition between them for assimilates. In agreement, Aloni *et al*. (1991) stated that an increase in total number of flowers and fruits has been shown to increase competition for photosynthates and thus, decrease fruit size.

Total fruit yield per plant and per hectare

Total fruit yield per plant and per hectare were not significantly ($P < 0.05$) affected by the stage of pruning. However, both parameters were highly significantly ($P < 0.01$) influenced by intensity of pruning (Table 3). The highest (174.94 g) total fruit yield per plant was obtained from one-reproductive organ pruned treatment and it was statistically at par with the control treatment. The lowest (159.54 g) was obtained from the three-reproductive organs pruned treatment, which was statistically at par with the two-reproductive organs pruned treatment. In the same manner, the highest (8334.4 kg) total fruit yield per hectare was obtained from one-reproductive organ pruned treatment and statistically at par with the control and the lowest (7543.20 kg) was obtained from three-reproductive organ pruned treatment. The observed reduction in total fruit yield per plant and per ha in response to an increased intensity of fruit pruning could be due to a significant reduction in fruit number and a concomitant loss in potential yield. The loss in total yield due to fruit number reduction could not be significantly compensated by an increase in fruit size in response to the pruning treatment. Similarly, Marcelis (1996) showed that distribution of assimilates among sinks is primarily regulated by the sink strength and generative sink strength is assumed to be proportional to the number of fruits. On the other hand, Heuvelink (1997) stated that the reduction in total fruit yield per plant can be explained by a decreased partitioning of assimilates to the fruits due to the reduced generative sink strength as a result of fruit pruning.

Conclusion

Concerning stage of pruning, even though it is difficult to decide the optimum time of pruning for better yield and yield component it can be concluded that stage of pruning had a lesser effect for yield components of pepper. All the parameters considered were affected by intensity of reproductive organs pruning. Therefore, for the determination of yield and yield component parameters of pepper, pruning intensity had a better magnitude effect than stage of pruning

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Table 4. Fresh and dry weight of individual fruit per plant, seed dry weight per fruit, total dry weight of fruit per plant and early yield per plant of pepper as affected by stage and intensity of reproductive organs pruning

Treatments	Fresh weight of individual fruit per plant (g)	Dry weight of individual fruit per plant (g)	Seed dry weight per fruit (g)	Total dry weight of fruit per plant (g)	Early yield per plant (g)
Stage					
Bud	5.73	2.19	0.52	46.68	102
Anthesis	5.51	2.22	0.51	47.28	99
Fruit set	5.73	2.08	0.52	45.28	101
F-test	ns	ns	ns	ns	ns
Intensity					
Control	4.23d	1.78c	0.40d	54.11a	110a
One-RO	5.00c	1.83c	0.47c	48.30b	101b
Two-RO	6.71b	2.31b	0.52b	44.50bc	96b
Three- RO	8.91a	2.72a	0.66a	38.72c	95b
F-test	**	**	**	**	**
CV (%)	10.8	10.97	6.91	12.76	8.2

ns and ** refers to non significant at 5% and significant at 1% probability level, respectively. Mean values within column followed by the same letter are not significantly different 1% probability level.
RO= Reproductive Organ

Table 5. The interaction effect of stage and intensity of reproductive organs pruning on seed number per fruit, vegetative and total dry weight of the plant and total leaf area of pepper

Treatment		Seed number per fruit	Vegetative dry weight of the plant (g)	Total dry weight of the plant (g)	Total leaf area (cm^2)
stage of pruning	Pruning intensity				
Bud	control	105.37e	57.97jk	104.65c-e	1118.60l
	One-RO	144.07b	59.31g-k	107.61b	1599.60i
	Two-RO	148.21a	61.69c-g	106.19bc	2538.42f
	three-RO	106.78e	68.49b	107.21bc	5251.56bc
Anthesis	control	103.79f	59.92f-j	107.2bc	1351.69jk
	One-RO	140.27c	58.62i-k	102.92e	1777.98hi
	Two-RO	142.97bc	61.40c-h	105.9bc	3275.20e
	three-RO	103.79f	71.87a	110.59a	5058.51c
Fruit set	control	100.15g	56.90k	102.18e	1282.11kl
	One-RO	131.19d	58.92h-k	107.22bc	2088.34g
	Two-RO	141.20c	62.73cd	107.23bc	4114.12d
	three-RO	105.04e	64.37d	103.09de	6945.88a
F-test		**	**	**	**
CV (%)		1.32	2.63	2.52	3.83

** refers to significant at 1% probability level. Means within a column followed by the same letter are not significantly different at 1% probability level.
RO = Reproductive Organ

Table 6. Marketable and unmarketable fruit yield per plant, and number of marketable and unmarketable fruit per plant as affected by stage and intensity of reproductive organs pruning

	Marketable fruit yield per plant (g)	Unmarketable fruit yield per plant (g)	Marketable fruit number per plant	Unmarketable fruit number per plant	Total fruit yield per plant (g)	Total fruit yield per ha (kg)
Treatments						
Stage						
Bud	160.65	6.49	26.53	2.62	167.14	7965.1
Anthesis	160.57	6.14	27.87	2.35	166.71	7895.5
Fruit set	159.36	6.22	26.7	2.20	165.58	7996.8
F-test	ns	ns	ns	ns	ns	ns
Intensity						
Control	165.59a	4.49b	36.44a	3.76a	170.08a	8099.50a
One-RO	170.63a	4.34b	31.96b	3.24b	174.94a	8334.40a
Two-RO	153.23b	8.06a	22.93c	1.51c	161.29b	7832.80b
Three-RO	151.30b	8.24a	16.80d	1.04d	159.54b	7543.20b
F-test	**	**	**	**	**	**
CV (%)	5.34	11.2	11.6	17.69	4.54	4.32

ns and ** refers to non significant at 5% and significant at 1% probability level, respectively. Mean values within column followed by the same letter are not significantly different at 1% probability level. RO = Reproductive Organs

References

Aloni, B., T. Pashkar and L. Karni, 1991. Partitioning of [^{14}C] sucrose and acid invertase activity in reproductive organs of pepper plants in relation to their abscission under heat stress. *Journal of Annals of Botany.* 67: 371-377.

Dorais, M. and A. Papadopoulos, 2001. Greenhouse tomato fruit quality. *Horticultural Reviews*. 26: 239-319.

Ehret, D., T. Helmer, and J. Hall, 1993. Cuticle cracking in tomato fruit. *Journal of Horticultural Science*. 68: 195-201.

Erik, A.M., S. de, G. Remmelt, K. Jos, S. Piet, F.M. Leo and E. Roeland, 2004. Non-destructive estimation of leaf area for different plant ages and accessions of *Capsicum annuum* L. *Journal of Horticultural Science and Biotechnology*. 79: 764-770.

Gebre Kiros, 2007. Effect of Nitrogen rates and varieties on yield and yield components of maize (*Zea mays* L.) under supplementary irrigation in Humbo woreda, Wolaita zone, Ethiopia. An MSc thesis presented to the School of Graduate Studies of Haramaya University. pp.20-21.

Guinn, G. and J.R. Mauney, 1980. Analysis of CO_2 exchange assumptions: feedback control. In: Hesketh JD, Jones JW, eds. predicting photosynthesis for ecosystem models III. Boca Raton, Florida: CRC Press. pp.1-16.

Heuvelink, E., 1997. Effect of fruit load on dry matter partitioning in tomato. *Journal of Horticultural Sciences.* 69: 51-59.

Heuvelink, E. and R. Buiskool, 1995. Influence of sink-source interaction on dry matter production in tomato. *Journal of Annals of Botany*. 75: 381-389.

Kinet, J.M. and M. Peet, 1997. Tomato. In: Wien, H. (Ed), *the physiology of vegetable crops*. CAB International, Wallingford, UK. pp.207-258.

Marcelis, L.F.M., 1991. Effects of sink demand on photosynthesis in cucumber. *Journal of Experimental Botany.* 42: 1387-1392.

Marcelis, L.F.M., 1996. Sink strength as a determinant of dry matter partitioning in the whole plant. *Journal of Experimental Botany*. 47: 1281-1291.

Tsedal, T., 2004. Yield and quality response of tomato and hot pepper to pruning, presented for partial fulfillment of the requirements of Master of Sciences in Agronomy. Department of Plant Production and Soil Sciences. South Africa, University of Pretoria. pp.1-132.

Van Ravestijn, W. and W. Molhoek, 1978. Glasshouse crops research and experiment station, Naaldwijk, the Netherlands. 41pp.

Zhiyuang, W., W. Deheng, and H. Xylin, 1982. The effects of flower thinning on Fruit and seed setting of sweet pepper, *Journal of Acta Agriculturae*. 8: 89-95.

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