J. Appl. Hort., 3(1):23-27, January-June, 2001

Effect of low-tunnel, mulch and pruning on the yield and earliness of tomato in unheated glasshouse

Levent Arin and Sözer Ankara

T.Ü. Agricultural Faculty, Department of Horticulture, 59030 Tekirdag-Turkey, E-mail: arinlevent@hotmail.com

Abstract

An experiment was carried out to determine the effect of low-tunnel, mulch and pruning treatments on yield and earliness tomato cv. Fuji F_1 tomato (*Lycopersicum esculentum* Mill.) in unheated glasshouse. Plant height, stem diameter, days to first harvest, early yield (g/plant), total yield (g/plant) and fruit weight (g/fruit) were determined during the growing period. Low-tunnel and mulching had a positive effect on plant growth development. The highest early yield was obtained from the plants pruned from the 4th truss and mulched with any mulch under low-tunnel. Total yield was highest in plants pruned from 8th truss and mulched with wheat straw .

Key words: Tomato, *Lycopersicum esculentum* Mill., low-tunnel, mulch, pruning, glasshouse, yield, days to harvest

Introduction

Green house cultivation has very short history in Turkey but now in practice from Yalova in the north to Samandag in the south along the coast. Tomato is one of the most important vegetable with the 50.9% planted area within the 14568.56 ha greenhouse area (Anonymous, 1993). The major restrictive factor for greenhouse cultivation is the high cost for heating during winters (Pekmezci *et al.*, 1990). Thus, profit can be increased in unheated greenhouse by passive heating methods like mulching, low tunnel, thermal curtains, etc. The low-tunnels, established during initial plant development stage in the greenhouse are the structures, which increases temperature 1-2 ^oC and enables the plant growing during critical development period (Sevgican, 1984). Mulching soil surface with the materials such as straw, manure, leaves, plastic etc. show positive effects on weed control, prevention of soil dryness and crusting, water saving by preventing evaporation from surface, prevention of soil vitality and increased nutrient intake. Increase in the photosynthesis due to CO_2 releases via disintegration of straw also increases soil temperature (Tressen, 1983, Var□ş, 1989, Abak *et al.*, 1990, Splittoesser, 1990, Yüksel, 1990).

Pinching off of the stem above certain fruit cluster is one of the basic applications in greenhouse tomato production. Sevgican (1989) observed that the leaves exhibited highest potential transpiration and the photosynthesis ability at 1.20m plant height and later when it reached to 1.85 m, photosynthesis was reduced. For increased early and quality fruit production, pinching at the growing point of plant, leaving 4 or 5 fruit cluster has been suggested by Ekinci (1960). Jarosiewcz and Gosiewski (1987) pruned the plants above 5-10 fruit cluster and found that earliness can be obtained by pinching at the 5-6 trussed, but total yield decreased. Early, high and regular yield was obtained from the 7-8 trussed plant. In 9-10 trussed plants, fruit yield increased but with comparatively short harvesting period.

The study was carried out with the aim of determining the effects of pruning operations, mulches and low-tunnel on tomato plant growth, earliness and total yield.

Materials and methods

The experiment was carried out at the research and application area of Tekirdag Agricultural Faculty of Trakya University in spring growing period. "Fuji F_1" tomato variety with 100-150g fruit weight and suitable for glass and plastic greenhouse was used (Anonymous, 1990). The seeds were sown in plastic tray (30 x 23 x 6 cm). Seedling were transplanted into black polyethylene bags 12 x 15 cm in size. Polyethylene sheet of 0.13 mm thickness was used for low-tunnel and mulching,.

The seeds were sown on 12 February into the tray which was filled with sterilised growing medium [1:1:1 ratio (the loam-clay soil, coarse river sand and dehydrated manure)] and placed into germination cupboard at the 21^{o}C. The seedlings, with cotyledon leaves parallel to ground, were transplanted into bags. Later, seedling were kept under the low-tunnel until planted in the field (4-5 true leaves stage).

Properties of greenhouse soil are given in Table 1 which was irrigated and cultivated upto 20-25 cm depth. Beds were prepared 1 m apart from each other. Black and transparent polyethylene mulch was laid down on the beds and holes were opened at 35 cm intervals for planting of the plants. Straw as mulch was laid down on the raised beds. Iron bars of low-tunnel were fixed at 1.5 m intervals. Seedlings were planted 11 April. Later on, tunnels were covered with transparent polyethylene and kept open in between 08 00 a.m. and 18 00 p.m. and kept closed in during night.

Table 1. Some properties of the glasshouse soil

Depth (cm)	pH	P_2O_5 (kg/ha)	K_2O (kg/ha)	Organic matter (%)
0-30	7.5	263.2	331.1	3.9

The required cultural practices during the growing period were followed as per Sevgican (1989) and the plants were supported by plastic twine and all side shoots and lower foliage was removed and the growing point was pinched off allowing three leaves above latest cluster. Maximum and minimum temperature values inside the glasshouse were recorded during the experiment (Table 2).

The harvesting of the marketable fruits at the red stage started on 9th June and completed on 6th August with the 16 times harvest.

Table 2. Maximum and minimum temperature in the glasshouse

Temperature (ºC)	Feb	Mar	Apr	May	Jun	Jul
Minimum	-1	0	-1	4	11	14
Maximum	32	31	36	37	35	35

The soil temperatures at 10 cm depth at pre-sown period the beginning of the plant development are given on Table 3.

Table 3. Soil temperatures measured at different times (°C)

	7/4/1995		25/4/1995		26/5/1995	
Mulches	WT	WOT	WT	WOT	TWT	WOT
Black polyethylene	13.8	12.4	23.8	23.1	25.6	21.5
Transparent polyethylene	14.1	12.0	29.7	24.3	24.9	22.5
Straw	14.1	13.0	22.8	21.0	21.1	20.7
Control	10.8	10.7	23.1	22.2	21.2	20.9

WT=With tunnel, WOT=Without tunnel

Plant height (cm) was measured from soil surface to top of the plant, stem diameter (mm) was recorded just above the cotyledon leaves, just after planting and before pruning. They were also expressed as percentage increase. The number of days for first harvest, early fruit yield (g/plant, first 5 harvest), total fruit yield (g/plant) and average fruit weight (g/fruit), total fruit weight/ number of fruit were recorded after planting and during harvest period.

The experiment was laid out in a split-split plot design with three replicates where each sub-sub plots have five plants. Main plot was low-tunnel applications (with tunnel, without tunnels) sub plot was mulch applications (transparent polyethylene, black polyethylene, wheat straw, and open (control) and sub-sub plot was related to pruning applications (cut off from 4^{th} or 8^{th} truss). Analyses of variance and LSD tests were conducted at p=0.05 confidence level by MSTAT programmes (Düzgüneº *et al.*, 1987).

Results

Analysis of variance (Table 4) show that the main effect of tunnel and mulch significantly influenced plant height (p=0.05). While 643.72 % increase in plant height (relative to height at the time of planting) was significant in plants grown under low-tunnel as compared to plant without tunnel (602.87%). The highest increase among the mulches was obtained with straw mulch (679.13%) while it was lowest in control. Differences in main effect on stem diameter were significant for tunnel and mulch with non significant interaction (Table 5).

Increase in stem diameter (265.36%) in the crop under low-tunnel was more than that without tunnel (233.83%). Straw and transparent polyethylene were at par. The effect under control treatment recorded non significant with black polyethylene. Differences between main effects of tunnel, mulch and pruning were significant whereas interaction were non significant for days required for first harvest (Table 6). The plants under low tunnel matured for harvest in 117.97 days and 119.88 days without tunnel.

The shortest time for harvest was recorded in transparent polyethylene (117.90 days) and this was at par with black polyethylene. The difference between wheat straw and control had no significance difference. The plants pruned above 4^{th} truss were harvested earlier than the plants pruned above 8^{th} truss. It is clear from Table 7 that tunnel, mulch and pruning main effects, tunnel x mulch interaction were significant for fruit yield of a plant at the first 5 harvests. The highest early yield was obtained as 1334.28g/plant under tunnel and mulched by black polyethylene, yet this was at par with tunnel x wheat straw and tunnel x transparent polyethylene effects. There is no significance influence on other applications. Early yield as 1236.54 g was obtained from plants which have been pruned above 4^{th} truss, were significantly higher than plants pruned above 8^{th} truss (Table 7).

The differences between mulch, pruning and tunnel x pruning applications have been found significant at p=0.05 in terms of total fruit yield (g/plant) (Table 8). The highest yield as 4482.22 g has been obtained from wheat straw among the mulching applications and it was followed by transparent polyethylene. Black polyethylene (3767.91g) and control (3757.37g) had no significant differences. Yield at 8^{th} truss pruned plant was 5077.49 g and 4^{th} truss pruned yielded 2998.93 g fruit/plant. The yield between 5288.41 g and 2991.47 g was recorded under different tunnel x pruning interactions (Table 8).

Mulch, pruning, mulch x pruning interaction and tunnel x pruning interaction have been found significant (p=0.05) for single fruit weight (Table 9). Heaviest fruit (119.93 g) was obtained from wheat straw among the mulches. 4^{th} truss pruned plants produced more fruit weight (121.36 g) compared to 8^{th} truss pruned ones (103.93g). The highest value of fruit weight (133.16 g) was among the mulch x pruning applications in the crop mulched with wheat straw and pruned from 4^{th} truss. Under tunnel x pruning interaction more fruit weight (125.49 g) was recorded under tunnel and 4th truss at the (Table 9).

Discussion

The increase in height and stem diameter of the crops grown under tunnel and mulched have been found much more than control plants (Table 4,5). Tressen (1983) reported that critical soil temperature is 14 ºC for tomatoes and the development stops or becomes slowly below this temperature. Gerber *et al.* (1988) reported that the pepper crop development increases by the increases of soil temperature due to tunnel effect. Salman *et al.* (1992) pointed out that mulching and tunnelling applications increases the soil temperature so that vegetative development and fruit yield of tomatoes increases in the conditions of unheated greenhouse. Higher soil temperature was observed in this experiment under the influence of mulch and tunnel relative to control and without tunnel ones which encouraged vegetative growth and development at the beginning initial stage of the crop (Table 3).

It could be explained that the plant mulched and pruned from 4^{th} truss are ready to harvest in short period due to mulches which increases the soil temperature and enable favourable conditions for nutrients, nutrient, metabolite mobilization and energy by existing fruits by means of pruning from 4^{th} truss

Table 4. The effect of tunnel and mulch applications on plant height[z]

Tunnels	Mulches: Transparent polyethylene		Black polyethylene		Straw		Control		Tunnel main effect	
	cm	%	cm	%	cm	%	cm	%	cm	%
WT	132.38	661.91	141.71	603.78	136.00	715.80	100.95	593.84	121.01	643.72a
WOT	112.17	623.20	94.24	589.00	115.64	642.45	100.09	556.84	105.54	602.87b
MME	122.28	642.55b	104.48	596.39c	125.82	679.13a	100.52	575.11c	113.28	623.29

WT=With tnnnel, WOT=Without tunnel, MME=Mulch main effect

z There is no statistical difference amongst the average bearing the same letters at 0.05 error level.

Table 5. The effect of tunnel and mulch applications on plant stem diameter[z]

Tunnels	Mulches: Transparent polyethylene		Black polyethylene		Straw		Control		Tunnel main effect	
	mm	%	mm	%	mm	%	mm	%	mm	%
WT	33.41	257.73	30.28	233.13	34.60	265.50	30.15	225.06	32.13	265.36 a
WOT	31.62	247.88	30.24	223.01	32.20	254.30	30.01	210.12	31.02	233.83 b
MME	32.52	252.80 a	30.25	228.07 b	33.41	259.90 a	30.35	217.59 b	31.57	239.59

WT=With tunnel, WOT=Without tunnel, MME=Mulch main effect

z There is no statistical difference amongst the average bearing the same letters at 0.05 error level.

(Babik, 1982, Tressen, 1983, Sevgican, 1989, Pekmezci *et al.*, 1990, Splittoesser, 1990).

Early fruit yield was higher in tunnelled and mulched treatments than the others. The crops pruned from 4th truss have more early yield than that pruned at 8th truss (Table 7). The results are in accordance with the findings of Pimpini *et al.* (1987) who have observed that low tunnel and transparent polyethylene mulch increases the earliness in two tomato varieties. Tressen (1983) recorded earliness and more yield with the 1-2 ^{o}C increase in temperature by the use of mulch. Wien and Minotti (1988) also observed favourable effect of mulches and 25 % yield increase in the first 4 harvests in tomato which was enabled by using transparent mulch. Mulching and pruning have given more yield than control in terms of early yield on pepper (Türkmen *et al.*, 1995). Jarosiewcz and Gosiewski (1987) recorded better effect of 5-6th truss pruning as compared to 9-10th truss pruning.

The total yield has been found highest (5288.41 g) in tunnelled and pruned 8th truss ones. Among the mulch applications, the wheat straw has given the highest yield while the control has given the lowest (Table 8). Also, fruit weight has been found much more at the crops grown under tunnel and mulched with straw and pruned from 4th truss (Table 9). The results have similarities with Pimpini *et al.* (1987) in which, mulch and tunnel increased the fruit weight, Gerber *et al.* (1988) observed that tunnelling increases the fruit yield and quality of pepper. Abak *et al.* (1990) recorded increase in yield of pepper (21%), eggplant (21 %), melon(67%) and water melon(98%) by mulch application. Contrary to these findings Babik (1982) recorded that pruning decreases total yield. Studies of Jarosiewcz and Gosiewski (1987) revealed that total yield of tomato pruned from 5-6th truss was lower than the total yield of 9-10th truss pruned ones. Studies with transparent, black polyethylene and wheat straw have shown significant effect of straw on total yield in tomato (Varis, 1989). The results that straw mulch gives higher yield and heavier fruit than the other application could be explained in light of beneficial effects of straw mulch which enables retention of soil moisture and prevent soil temperature to rise high at the end of vegetative phase which enables increase in the CO_2 content, which results in increased photosynthesis (Varis, 1989, Witter and Honma, 1979).

The present investigation revealed that, low tunnel are useful for encouraging crop development during initial stage of plant, early harvest and high total yield. The use of one of the mulches placed in the experiment and pruning from 4th truss is useful for

Table 6. The effects of tunnel, mulch, and pruning applications on number of days to first harvest[z]

Main Effects and Interactions	Pruning Mulch and Tunnel		4th Truss	8th Truss	Main effects and interactions
Mulch × Pruning interaction and Mulch main effect		Transparent polyethylene	117.47	118.33	117.90a
		Black polyethylene	117.73	118.60	118.17a
		Straw	119.60	119.93	119.77b
		Control	119.13	119.97	119.85b
Tunnel × Pruning interaction and Tunnel main effect		With Tunnel	117.63	118.30	117.97a
		Without Tunnel	119.63	120.18	119.88b
Tunnel × Mulch and Tunnel × Mulch × Pruning Interaction	With Tunnel	Transparent polyethylene	116.07	117.13	116.60
		Black polyethylene.	116.60	117.60	117.10
		Straw	118.87	119.20	119.03
		Control	119.00	119.27	119.13
	Without Tunnel	Transparent polyethylene	118.87	119.53	119.20
		Black polyethylene	118.87	119.60	119.20
		Straw	120.33	120.67	120.50
		Control	120.47	120.67	120.59
Pruning main effect			118.63a	119.21b	118.92

zThere is no statistical difference among the average bearing the same letters at 0.05 error level

Table 7. The effects of tunnel, mulch, and pruning applications on early yield (g / plant) [z]

Main Effects and Interactions	Pruning Mulch and Tunnel		4th Truss	8th Truss	Main effects and interactions
Mulch × Pruning interaction and Mulch main effect		Transparent polyethylene	1285.02	1064.26	1174.64a
		Black polyethylene	1275.22	1128.62	1201.92a
		Straw	1253.31	1142.73	1198.08a
		Control	1137.60	922.78	1062.69b
Tunnel × Pruning interaction and Tunnel main effect		With Tunnel	1137.35	1163.87	1250.01a
		Without Tunnel	1137.72	1000.32	1068.02b
Tunnel × Mulch and Tunnel × Mulch × Pruning Interaction	With Tunnel	Transparent polyethylene	1410.47	1141.44	1275.96 a
		Black polyethylene.	1413.39	1255.16	1334.28a
		Straw	1356.56	1250.60	1303.58a
		Control	1168.98	1008.30	1088.64b
	Without Tunnel	Transparent polyethylene	1159.57	987.07	1073.32b
		Black polyethylene	1137.05	1002.08	1069.57b
		Straw	1150.06	1034.86	1092.46b
		Control	1096.20	977.27	1036.73b
Pruning main effect			1236.54 a	1082.10 b	1159.32

Table 8. Effect of tunnel, mulch, and pruning applications on total yield (g / plant) [z]

Main Effects and Interactions	Pruning Mulch and Tunnel		4th Truss	8th Truss	Main effects and interactions
Mulch × Pruning interaction and Mulch main effect		Transparent polyethylene	3089.76	5200.92	4145.34b
		Black polyethylene	2704.28	4831.54	3767.91c
		Straw	3472.98	5491.46	4482.22a
		Control	2728.70	4786.03	3757.37c
Tunnel × Pruning interaction and Tunnel main effect		With Tunnel	2991.47c	5288.41a	4140.05
		Without Tunnel	3006.16c	4866.56b	3936.36
Tunnel × Mulch and Tunnel × Mulch × Pruning Interaction	With Tunnel	Transparent polyethylene	3066.58	5429.16	4247.87
		Black polyethylene.	2729.01	5071.50	3905.25
		Straw	3419.52	5725.32	4572.42
		Control	2741.67	4927.66	3834.67
	Without Tunnel	Transparent polyethylene	3112.93	4972.67	4042.80
		Black polyethylene	2669.55	4591.58	3630.56
		Straw	3526.44	5257.60	4392.02
		Control	2715.73	4644.40	3680.07
Pruning main effect			2998.93b	5077.49a	4038.21

zThere is no statistical difference among the average bearing the same letters at 0.05 error level

Table 9. Effect of tunnel, mulch, and pruning applications on fruit weight (g/fruit) [z]

Main Effects and Interactions	Pruning Mulchand Tunnel		4th Truss	8th Truss	Main effects and interactions
Mulch × Pruning interaction and Mulch main effect		Transparent polyethylene	123.55b	104.69ef	114.12b
		Black polyethylene	111.62d	100.84f	106.23d
		Straw	133.16a	106.70de	119.93a
		Control	117.10c	103.50ef	110.30c
Tunnel × Pruning interaction and Tunnel main effect		With Tunnel	125.49a	104.43c	114.96
		Without Tunnel	117.22b	103.43c	110.33
Tunnel × Mulch and Tunnel × Mulch × Pruning Interaction	With Tunnel	Transparent polyethylene	125.38	104.90	115.14
		Black polyethylene.	118.40	100.83	109.62
		Straw	134.68	108.21	121.45
		Control	123.50	103.79	113.64
	Without Tunnel	Transparent polyethylene	121.71	104.47	113.09
		Black polyethylene	104.83	100.84	102.84
		Straw	131.64	105.20	118.42
		Control	110.70	103.21	106.96
Pruning main effect			121.36a	103.93b	112.64

zThere is no statistical difference among the average bearing the same letters at 0.05 error level

increasing the early yield. For high total yield, wheat straw as a mulch and pruning from 8th truss could be used, but the consideration could be taken that the crops pruned from 4th truss produce larger fruit.

References

Abak, K., N. Gürsöz, Y. Pakyürek ve R. Onsinejad, 1990. Malç Uygulamalarinin Serada Toprak Sicakligi ile Bazi Sebzelerin Verim ve Erkencilik Üzerine Etkisi. Türkiye 5. Seracilik Sempozyumu, Izmir. 5:55-62.

Anonymous, 1980. Domates, T.S.E. 794. Türk Standartlari Enstitüsü, Ankara.

Anonymous, 1990. Tohumluk Programi. T.C. Tarim ve Köyisleri Bakanligi Tarim Üretim ve Gelistirme Genel Müdürlügü, Ankara.

Anonymus, 1993. Beº Yillik Kalkinma Plani Örtüalti Sebze Yetistiriciligi Özel Ihtisas Komisyon Raporu. Seracilik Arastirma Enstitüsü, Antalya.

Babik, S., 1982. Effect of Pruning and Decapitating on the Earliness of Tomatoes Grown in Heated Plastic Tunnels. Biuletyn Warzy Wniczy, Poland, pp: 201-212.

Düzgünes, O., T. Kesici, O. Kavuncu ve F. Gürbüz, 1987. Arastirma Deneme Metodlari, Istatistik Metodlari. A.Ü. Ziraat Fakültesi, Yayinlari No. 1021, Ankara, 381s.

Ekinci, A.S., 1960. Kârli Domates Yetistirilmesi. Yenilik Basimevi, Istanbul, 64 s.

Gerber, J.M., I. Mohd-Khir, and W.E. Splittoesser, 1988. Row Tunnel Effects on Growth, Yield and Fruit Quality of Bell Pepper. *HortScience,* 26(3-4):191-197.

Jarosiewcz, S. and W. Gosiewski, 1987. Leaf and Fruit Growth of Greenhouse Tomatoes in Relation to the Number of Truses on Hormone Treatment. Zesyty Naukowe Akedemi Rolniczey im Hugone Kallataja Krokowie, Ogradnic two, 210:11-140.

Pekmezci, M., M. Erkan, M. Akilli ve N. Ercan, 1990. Farkli Isi Perdelerinin Cam Serada Yetistirilen Önemli Hiyar Çesitlerinin Erkencilik, Verim ve Kalitesi Üzerine Etkileri. Türkiye 5. Seracilik Sempozyumu, Izmir, 5:243-254.

Pimpini, F., G. Granguinto, G. Babbo and E. Xodo, 1987. The Effect of Protective Structures and of Pinching on the Earliness of Table Tomatoes in the Greenhouse. *Prottte*, 16(8/9):63-73.

Salman, S.K., A.F. Abou-Hadid, I.M.J. Beltagy and A.S. Beltagy, 1992. Plastic House Microclimate as Affected by Low Tunnels and Plastic mulch. *Egyptian J. of Hort.* 2:111-119.

Sevgican, A., 1984. Alçak Plastik Tüneller. Ege Üniv. Zir. Fak. Dergisi, 21(1):101-104.

Sevgican, A., 1989. Örtüalti Sebzeciligi. T.A.V. Yayinlari No. 19, Yalova.

Splittoesser, W.E., 1990. Vegetable Growing Handbook. Third Edition, Van Nostrand Reinhold, New York, 362 p.

Tressen, T., 1983. Polyethylene Mulches in Vegetable Production. Order No. 78-008, Ontario, 4 p.

Türkmen, O., A. Karatas, S. Akinci ve I.E. Akinci, 1995. Plastik Serada Yetistirilen Sivri ve Dolma Biberin Verim ve Erkenciligi Üzerine Malç ve Budamanin Etkileri. Türkiye 2. *Ulusal Bahçe Bitkileri Kongresi, Adana, cilt* 2:87-92.

Varýs, S., 1989. Malç ve Çesit Interaksiyonunun, Kuru Sartlarda Açikta Yetistirilen Domateslerin Gelisme ve Verimine Etkisi. Tekirdag Zir. Fak. Yayinlari No. 73, Arastirmalar No.22, 30 s.

Wien, H.C. and P.L. Minotti, 1988. Increasing Yield of Tomatoes with Plastic Mulch and Apex Removal. *J. Amer. Soc. Hort. Sci.*, 113(3):342-347.

Witter, S.H. and S. Honma, 1979. Greenhouse Tomatoes, Lettuce and Cucumbers. East Lansing, Michigan University Press.

Yüksel, A.N., 1990. Sera Yapim Teknigi. Tekirdag Zir. Fak. Yayin No.86, 29