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Tüzel Y., Eltez R.Z., Altin O.

in

Choukr-Allah R. (ed.).
Protected cultivation in the Mediterranean region

Paris : CIHEAM / IAV Hassan II
Cahiers Options Méditerranéennes; n. 31

1999
pages 391-396

EFFECTS OF DIFFERENT POLLINATION AND FRUIT SET PRACTICES ON LONG SEASON TOMATO PRODUCTION IN GLASSHOUSES

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Abstract: Tomato production in unheated greenhouses during the winter is limited due to unfavorable climatic conditions. For this reason, in practice, some methods have been applied to improve pollination and fruit set. This investigation was conducted in two glasshouses to determine the effects of (a) control, (b) truss vibration, (c) hormone, (d) bumblebees + vibraton and (e) bumblebees (*Bombus terrestris*) on long season tomato production. Seeds of cv. Elif 190 were sown on the 1st of September and planted to the glasshouses on the 9th of November in 1995. Four hives, provided from Biobest (Belgium), were used for proper bumblebee pollination from November until March. Trusses were vibrated twice a week for 1-2 seconds. Hormone (Pandomine) was applied only once per truss. Plant growth was stopped by topping above the 8th cluster. Yield (kg/m^2) and fruit quality parameters (size, TA, pH, TSS, vit. C, dry matter content, carpel and seed number, pericarp thickness) were determined. The highest yield was obtained from bumblebees. Bumblebees resulted in an increase of fruit weight, also. Hormone treatment caused an increment of fruit number.

INTRODUCTION

In Turkey, tomato is the most important crop and accounts for 51% of 14600 hectares of land devoted to greenhouse vegetable production (Anon., 1993).

The production is realized in unheated greenhouses during winter that therefore it is limited with the prevailing climatic conditions. Fruit set and the proportion of marketable sized fruits, which are the components of tomato yield, are the most important problems because of environmental factors, such as low temperature (Atherton and Harris, 1986), low light intensity and low temperature combined with high humidity (Picken, 1984).

Low temperature and low irradiation result in improper ovary development, malformation of the flowers and production of unviable pollen (Rylski and Aloni, 1994). Thus, auxins are commonly used by growers for fruit set even though they may cause losses in fruit quality on a large scale.

High humidity, which is a general problem in the greenhouses of the Mediterranean region, results in an insufficient number of viable pollens reaching the stigma. In practice, mechanical aids such as vibration by hands, electrical means or bumblebees to stimulate pollination are extremely efficient in increasing fruit set (Tüzel et al., 1992; Ilbi and Boztok, 1994).

The present study aims to investigate the effects of different pollination and fruit set practices on tomato yield and fruit quality parameters in long season tomato production.

MATERIAL AND METHODS

The experiment was conducted between 1955 and 1996 in two glasshouses of the Department of Horticulture, Faculty of Agriculture at Ege University.

Tomato (*Lycopersicon esculentum* Mill.) cultivar Elif 190 (F_1) was used in trials. The sowing, transplanting and planting dates were September 1, September 12 and November 9, 1995, respectively. The plants were spaced at 70x40 cm distances and topped at the 8th cluster.

The following treatments were tested in the trial;

1. Control (Untreated)

2. Truss vibration: Trusses were vibrated twice a week for 1-2 seconds at 10.00 a.m. by 9 volt "polli-bee".

3. Hormone: Pandomine (4CPA) was applied only once per truss at the onset of flowering when 3-4 flowers were at anthesis.

4. Bumblebees + vibration: Vibration was applied in addition to bumbles.

5. Bumblebees: Four *Bombus terrestris* hives, provided from Bio-best (Belgium) were used for proper bumblebee pollination from November until March in one of the glasshouses which had polyester netting in ventilation windows in order to prevent escaping of bumblebees.

The treatments beside bumblebees, 1st, 2nd and 3th were carried on an adjacent glasshouse. The experimental design was "randomized parcels" with 3 replicates.

Fruit harvest started on 26 February, 1996 and continued until 17 June, 1996. Fruits were then classified into different sizes according their diameters and grouped as 1^{st} (0>4.5 cm), 2^{nd} (4.5>0>3.5 cm) and 3^{rd} (0<3.5 cm).

The amount of total soluble solids (TSS) (Hortwirth, 1960), total dry matter , pH, titratable acidity (TA) (Joslyn, 1970), vitamin C (Morell, 1941), pericarp thickness and carpel and seed numbers were determined in fruit samples taken at two weeks intervals during the harvest period.

RESULTS AND DISCUSSION

Yield and fruit size

Besides the total yield determined as fruit number and average fruit weight were also measured for each truss.

The highest yield (9.5 kg/m^2) was obtained from bumblebees and followed by hormone treatments. The yield increases obtained by the use of bumbles were 11.18%, 11.51%, 43.39% and 104.32% compared with hormone, bumbles+vibration, truss vibration and control, respectively (table 1).

Table 1. The comparison of yield (kg/m^2) according to treatment and trusses

Treatments	Truss no								
	1	2	3	4	5	6	7	8	Total
Control	0.439 b	0.291	0.370 b	0.313	0.691	0.650 b	0.850 b	1.050 c	4.654 d
Truss vibration	1.211 a	0.495	0.368 b	0.281	0.750	0.830 b	0.940 b	1.665 b	6.540 c
Hormone	1.482 a	0.828	0.801 a	0.429	0.816	0.936 b	1.468 a	1.794 b	8.553 ab
Bumblebee+ Vibr.	1.122 a	0.524	0.219 b	0.522	1.137	0.943 b	1.595 a	2.172 ab	8.232 b
Bumble bee	1.176 a	0.671	0.263 b	0.481	1.094	1.604 a	1.8655 a	2.354 a	9.509 a
LSD ($_{0.05}$)	0.371	n.s.	0.268	n.s.	n.s.	0.376	0.457	0.561	1.246

The effect of hormone application on yield was significantly higher only in the 3rd week. Although the fruit numbers were not influenced except the 1st and 3rd trusses (table 2).

Table 2. The change of fruit numbers in the treatments

Treatments	Truss no								
	1	2	3	4	5	6	7	8	Total
Control	8.254 b	8.889	10.595 a	7.103	17.143	16.547	20.502	26.190	115.368
Truss vibration	15.516 a	10.661	10.833 a	7.645	17.602	19.791	17.526	30.939	130.514
Hormone	14.868 a	14.669	12.738 a	9.167	15.661	16.296	22.129	25.512	131.040
Bumble bee+ Vibr.	12.088 a	7.555	4.258 b	11.401	15.659	12.145	19.119	22.481	104.705
Bumble bee	10.574 a	7.753	4.406 b	9.045	15.497	19.348	21.703	24.800	113.126
LSD ($_{0.05}$)	4.953	n.s.	4.940	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

The changes among treatments in terms of fruit weights were found significant (table 3). Bumblebees always gave the best result in respect to this parameter.

Table 3. Effects of the treatments on fruit weights (g)

Treatments	Truss no								
	1	2	3	4	5	6	7	8	Average
Control	52.675 d	32.759 d	35.744 b	44.316	43.325 b	39.598 c	43.736 c	40.063 c	41.527 e
Truss vibration	78.256 c	49.607 cd	33.792 b	36.298	43.618 b	41.794 c	53.702 bc	54.486 c	48.994 d
Hormone	100.139 ab	54.832 bc	62.192 a	48.123	52.230 b	59.010 b	66.944 b	71.145 b	64.327 c
Bumble bee+ Vibr.	92.050 bc	69.977 ab	55.995 a	46.452	71.440 a	79.694 a	84.056 a	96.254 a	74.489 b
Bumble bee	111.374 a	86.236 a	60.891 a	53.297	70.527 a	82.428 a	85.941 a	95.150 a	80.730 a
LSD ($_{0.05}$)	16.061	17.387	15.541	n.s.	14.274	15.040	15.040	15.750	6.052

The classification of fruits also showed that the fruits which had larger diameters were obtained from bumbles followed by bumbles+vibration and hormone treatments (table 4 and 5).

Table 4. The fruit diameter values obtained in different treatments (%)

Treatments	Diameter (cm)									
	<3.5	3.5-4	4-4.5	4.5-5	5-5.5	5.5-6	6-6.5	6.5-7	7-7.5	7.5-8	8>
Control	3.63 a	7.34	19.88 a	26.55 a	23.11	7.78	6.90 c	1.84 c	1.98 b	0.60	0.53
Truss vibration	2.19 b	6.19	17.38 ab	24.92 a	21.49	9.23	7.01 c	5.67 bc	2.77 b	2.10	0.55
Hormone	2.00 b	4.18	10.55 bc	16.65 b	19.45	11.79	12.99 b	10.03 ab	10.97 a	1.70	0.27
Bumble bee+Vibr.	1.86 b	3.65	8.86 c	20.32 ab	17.25	9.31	18.87 a	7.17 abc	9.58 a	3.50	0.60
Bumble bee	1.39 b	2.75	8.51 c	15.24 b	18.39	8.90	16.23 ab	13.65 a	11.48 a	8.10	1.55
LSD ($_{0.05}$)	1.079	n.s.	7.142	5.567	n.s.	n.s.	4.033	6.627	5.396	n.s.	n.s.

Table 5. Effect of the treatments on the percentage of the 1st, 2nd and 3rd classes of fruits

Treatments	<3 (3rd)	3.5-4.5 (2nd)	4.5> (1st)
Cýntrol	3.63 a	27.18 a	69.23 b
Truss Vibration	2.19 b	23.55 a	73.71 b
Hormone	2.00 b	14.71 b	83.87 a
Bumble bee+Vibration	1.86 b	12.44 b	85.31 a
Bumble bee	1.39 b	12.61 b	85.36 a
$LSD_{(0.05)}$	1.079	5.481	5.815

In greenhouse trials, the use of different vibration treatments to ensure pollination in tomatoes proved to be effective in increasing the weight of fruit (Ercan and Vural, 1994) and bumblebee species for pollination was found to be beneficial from the economic point of view and for yield increases and is considered promising (Sande and van de Sande, 1989; Banda and Paxton, 1991; Colombo et al., 1992).

Fruit Quality

Treatments had no effect on the number of carpels, whereas, seed number and pericarp thickness showed significant differences in the treatments (table 6) and both parameters increased with the use of bumblebees+vibration. Dempsey and Boynton (1966) reported that there is a relationship between fruit weight and the number of seeds, therefore the number of seeds determines the fruit weight. Satti (1986) and Ercan et al., (1992), have also obtained similar results showing that mechanical aids increased both the number of seeds and fruit weight.

Table 6. The number of carpels and seeds and pericarp thickness

Treatments	No of carpel	No of seeds	Pericarp thickness (cm)
Control	2.836	2.00 c	0.6375 c
Truss Vibration	2.738	14.6 b	0.6896 b
Hormone	2.661	5.70 c	0.7152 b
Bumble bee+Vibration	2.701	31.1 a	0.7840 a
Bumble bee	2.772	35.5 a	0.8059 a
$LDS_{(0.05)}$	n.s.	7.099	0.03510

Hormone application promotes parthenocarpic fruit set, thus there are less seeds and plasentha but thicker pericarp thickness within the fruits (Koçer and Eser, 1992).

The effects of the treatments on total soluble solids (TSS) and total dry matter content were not significantly different, whereas, vitamin C, pH and titratabe acidity (TA) values changed depending on the treatments (table 7). The results obtained from the analysis of the chemical quality components showed that environmental conditions occuring during the fruit set had more significant effects on these parameters (Picken et al., 1985; Ho et al., 1987).

Table 7. TSS, total dry matter content, vit. C, pH and TA values

Traetments	TSS (%)	Total dry matter content (%)	Vit. C (mg/100 ml)	pH	TA (meq/100ml)
Control	4.355	5.737	9.054 c	4.535 a	7.363 a
Truss Vibration	4.236	5.725	9.888 a	4.532 ab	6.957 b
Hormone	4.373	5.707	9.725 ab	4.527 abc	7.163 a
Bumblebee+Vibration	4.269	6.002	9.275 bc	4.492 c	7.429 a
Bumblebee	4.256	5.663	9.175 c	4.439 d	7.584 a
$LSD_{(0.05)}$	n.s.	n.s.	0.464	0.0376	0.3592

REFERENCES

Anonymous, 1980. Richtlinien zur Planung. Anlage und Auswertung von Versuchen im Gemüsebau. Boon Bad. Godesberg

Anonymous, 1993. VIIth Five Years Development Plan. Report of the commission of experts working on greenhouse vegetable growing. State Planing Organization, Turkey.

Atherton, J.G., Harris, G.P., 1986. Flowering.In The Tomato Crop (ed. by J.G. Atherton and J. Rudich). Chapman and Hall Inc. London p.167-200.

Banda, H.J., Paxton, R.J., 1991. Pollination of greenhouse tomatoes by bees. Acta Horticulturae, 288:194-198.

Colombo, A., Nucifora, S., Nucifora, M.T., Calabo, M., 1992. Use of B.terrestris in the pollination of tomato. Colture Protette, 21:12, 75-81.

Dempsey, W.H., Boynton, J.E., 1966. Effect of seed number on tomato fruit size and maturity. American Soc. for Hort.Sci., 86:575-581.

Ercan, N., Vural, H., Akìllì, M, Pekmezci, M., 1994. An investigation on the effects of vibration and hand pollination on fruit set, seed number and fruit weight of tomatoes. 1st National Hort. Cong., Vol. 2: 343-347. Izmir.

Ercan, N., Vural, H., 1994. The effects of low temperatures on fruit set of tomatoes. Acta Horticulturae, 366:65-73.

Ho, L.C., Grange, R.I., Picken, A.J., 1987. An analysis of the accumulation of water and dry matter in tomato fruit. Plant, Cell and Environment 10: 157-162.t

Ilbi, H., Boztok, K., 1994. The effects of different truss vibration durations on pollination and fruit set of greenhouse grown tomatoes. Acta Horticulturae, 366:73-78.

Koçer, G., Eser, B., 1992. A study on the comparison of 2,4 D applications in different forms and doses on greenhouse tomato production. 1st National Hort. Cong., Vol. 2: 349-351. Izmir.

Morell, S.A., 1941. Rapid Photometric Determination of Ascorbic Acid in Plant Materials. Ind. Eng. Chem. Analy. 13:793.

Picken, A.J., 1984. A review of pollination and fruit in the tomato (L. esculentum Mill.) Journal of Hort. Sci. 59 (1):1-3.

Picken, A.J.F., Hurd, R.G., Vince-Prue, D., 1985. Lycopersicon esculentum. CRC Handbook of Flowering (Ed. by Halery). Vol.III:331-346. CRC Press Inc. Florida.

Rylski, I., Aloni, B., 1994. Flowering, fruit set, fruit development and fruit quality under different environmental conditions in tomato and pepper crops. Acta Horticulturae, 366:45-56.

Sande, J. van de., Sande, J., 1989. Insect pollination Bumblee bees are a good alternate the truss vibration for beefsteak tomatoes. Groenten en Fruit, 45:20, 40-41.

Satti, S.M.E., 1986. Artificial vibration for increasing fruit set of tomato under arid conditions. Acta Horticulturae, 190:455-457.

Tüzel, Y., Gül, A., Sevgican, A., 1992. An investigation on the effects of some treatments on fruit set of greenhouse tomatoes grown in autumn. 1st National Horticultural Congress, Vol 2, 339-342. Izmir.