

Full Length Research Paper

Effect of different organic fertilizers on yield and fruit quality of indeterminate tomato (*Lycopersicon esculentum*)

Dürdane YANAR¹, Naif GEBOLOĞLU^{2*}, Yusuf YANAR¹, Mine AYDIN² and Perihan ÇAKMAK²

¹Department of Plant Protection 60240, Agricultural Faculty, Gaziosmanpaşa University, Tokat, Turkey.

²Department of Horticulture 60240, Agricultural Faculty, Gaziosmanpaşa University, Tokat, Turkey.

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The purpose of this study was to evaluate the effects of different organic fertilizers on yield and fruit qualities of indeterminate tomato. Influences of different organic and inorganic fertilizers on yields and fruit quality of tomato were compared during 2006 and 2007 growing periods under field conditions. In 2006 growing period, organic fertilizers used were Ormin K (250 kg/ha before planting; 30 kg/ha after first flowering; 80 kg/ha after first harvest), Coplex (50 kg/ha every week from planting to last harvest), Nof (40 kg/ha every week, from planting to last harvest), composted poultry manure (CPM) (1 t/ha before planting; 0.5 ton/ha after first flowering and 0.5 ton/ha after first harvest (liquid form)) and composted cattle manure (CCM) (60 t/ha before planting; 5 ton/ha after first flowering and 5 ton/ha after first harvest (liquid form)). Based on the first year results, organic fertilizers used during 2007 growing periods were F1 (20 ton/ha CCM before planting; 1 t/ha CPM before planting; 40 kg/ha Coplex and 20 kg/ha Nof every week) and F2 (20 t/ha CCM before planting; 500 kg/ha Ormin K before planting; 30 kg/ha Coplex and 30 kg/ha Nof every week). Inorganic fertilizers used as a control were N: 450, P₂O₅: 350, K₂O: 600, CaO:50, S: 200, and Mg:50 kg/ha. Tomato cultivars used in this study were Alida F₁ in 2006 growing period and Alida F₁, Yankı F₁ and Maya F₁ in 2007 growing period. In 2006, the highest yields obtained from CPM, CCM, and control treatments were 128.12, 122.92 and 115.24 t/ha respectively. In 2007, marketable yield obtained from F1 fertilizer treatment was similar to the control application. Unmarketable yield was not affected from the different fertilizer treatments. There was no significant difference among the treatments. However fruit cracking rates were higher in organic fertilizer treatments than the inorganic fertilizer treatment. Finally, application of 20 to 40 t/ha composted cattle manure before planting and addition of commercial organic fertilizers such as coplex, nof and ormin K can be used as an alternative to the chemical fertilizers in indeterminate tomato cultivation.

Key words: Tomato, organic fertilizer, cattle manure, poultry manure, yield.

INTRODUCTION

The industrial revolution followed by green revolution caused increase in yield per unit area in agricultural production, but they also caused increase in synthetic fertilizers and pesticides used in agriculture. Intensive inorganic fertilizer usage in agriculture caused so many health problems and unrecoverable environmental pollution. To reduce and eliminate the adverse effects of

synthetic fertilizers and pesticides on human health and environment, new agricultural practices have been developed in the so-called organic agriculture, ecological agriculture or sustainable agriculture. (Aksoy, 2001; Chowdhury, 2004).

The organic fertilizers take the place of inorganic fertilizers in sustainable agriculture. The main sources of the organic fertilizers are composted livestock manures, plant residues and industrial wastes. The organic fertilizers provide the nutritional requirements of plants and also suppress the plant pests populations.

*Corresponding author. E-mail:naif.gebologlu@gop.edu.tr.

Table 1. Nutrient element content of organic fertilizers.

Fertilizers	Macronutrients (%)						Micronutrients (ppm)					
	N	P	K	Ca	Mg	S	Fe	Cu	Mn	Mo	B	Zn
OK	1.2	0.1	35.5	3.0	1.0	31.5	60.0	6.0	34.0	0.5	-	7.0
CO	3.5	0.1	9.5	1.0	0.1	1.0	80.0	0.5	40.0	---	13.0	60.0
Nof	2.0	0.5	2.0	---	0.6	2.0	60.0	---	29.0	---	20.0	10.0
CPM	2.0	1.9	1.5	5.0	0.7	0.4	1.3	66.0	330.0	3.3	28.0	314.0
CCM	1.5	0.8	4.5	2.1	0.9	0.5	2.0	51.0	180	3.5	6.0	164.0

Additionally, they increase the microbial activity in soil, anion and cation exchange capacity, organic matter and carbon-content of soil. Organic fertilizers increase the yield and quality of agricultural crops in ways similar to inorganic fertilizers (Singh and Siataramaiah, 1970; Hoiink and Boehn, 1999; Bulluck and Ristaino, 2002; Bulluck et al., 2002; Arancon et al., 2004; Heeb et al., 2005a; Heeb et al., 2005b; Heeb et al., 2006; Liu et al., 2007; Tonfack et al., 2009).

Tomato is one of the organically produced vegetables and one of the most important vegetable crops in Turkey with 11 million tons of annual production (FAO, 2008). At present, tomato production is mainly conventional both in open field and in greenhouse in Turkey. However, farmers have started to use organic fertilizers beside the inorganic fertilizers in tomato production. Interests in organic agriculture is rapidly increasing among farmers. Such that several organic or organo-mineral fertilizers now appear in Turkish fertilizer markets. Some of these products have certificates for organic agriculture.

The aim of this study was to investigate the effect of different organic fertilizers on yield and some quality parameters in a two-year field study.

MATERIALS AND METHODS

This study was carried out under field conditions in Tokat during 2006 to 2007 growing seasons. Tokat is located between 40°19'07" north and 36°33'11" west coordinates with an altitude of 610 meters. Annual vegetable production of Tokat is about one million tons.

Fertilizers

The organic fertilizers used in this study are Ormin K (OK), Coplex (CO) and Nof. Additionally, composted poultry manure (CPM), composted cattle manure (CCM) and inorganic fertilizers (Control) were also used. During the field trials different doses of organic fertilizers were tested in 2006 to 2007. The fertilizers and their doses used in 2007 were determined after evaluation of first year data. The organic fertilizers used in this study and their contents were given in Table 1. Dosage and application times of fertilizers were showed in Table 2.

Plant materials

Tomato cultivars used in this study were Alida F1 (Zeraim Gedera

Seed Co) in 2006 growing period and Yankı F1 (İstanbul Seed Co), Maya F1 (May Agro Seed Co) and Alida F1 in 2007 growing period. Tomato seedlings were planted with 50 cm narrow row and 120 cm wide row spaces and 40 cm spacing between plants (29400 plants/ha). Plants were trained with single stem and trimmed after eighth cluster. Organic and chemical pesticides and fungicides were used in organic and inorganic fertilizer plots respectively for control diseases and pests.

The tomato fruits were separated into three quality classes according to UNECE Tomato Standards as extra class yield, first class yield and second class yield after each harvest (Anonymous, 2009). The total marketable yield, early yield (first 8 harvest), average fruit weight, unmarketable yield, distribution of yield to the quality classes and rate of cracked fruit were determined.

Statistical analysis

The effects of fertilizers and cultivars were analysed using ANOVA, with means separated by the LSD test ($P \leq 0.05$). Different letters in the table represent significant variations.

RESULTS

2006 experiment

The best plant development was achieved from the composted poultry and cattle manures application as compared to other organic fertilizers and control treatments. The highest marketable yields were obtained from CPM and CCM treatments with 128.12 and 122.92 t/ha respectively. The marketable yield was significantly higher in CPM and CCM than the others ($P \leq 0.05$). The number of fruits per plant followed a similar pattern as the marketable yield (Table 3). The number of fruits per plant for the CPM and CCM treatments were 41.13 and 39.12 fruits respectively. Fruit number were not significantly different between CPM and CCM treatments. However the fruit number per plant in CPM treatment was significantly different than the other fertilizer treatments and control application ($P \leq 0.05$) (Table 3). The average fruit weight from the CPM and CCM treatments were higher than the other treatments but there was no significant differences among them. The extra class yield were higher in CPM, CCM and control treatments than the other fertilizer treatments. The extra class fruit number per plant followed a similar pattern as the extra class yield (Table 3).

Table 2. Application time and doses of fertilizers.

Year	Fertilizers	Application time and doses
2006	OK	250 kg/ha before planting; 30 kg/ha after first flowering; 80 kg/ha after first harvest
	CO	50 kg/ha every week from planting to last harvest
	Nof	40 kg/ha every week, from planting to last harvest
	CPM	1 t/ha before planting; 0,5 t/ha after first flowering (liquid form), 0.5 t/ha after first harvest (liquid form)
	CCM	60 t/ha before planting; 5 t/ha after first flowering (liquid form), 5 t/ha after first harvest (liquid form)
	Control (kg/ha)	N:450; P ₂ O ₅ : 350; K ₂ O: 600; CaO: 50 ; S: 200; Mg:50
2007	F1: CPM +CO+Nof	20 t/ha CCM before planting; 1 t/ha CPM before planting, 40 kg/ha CO every week ; 20 kg/ha Nof every week
	F2: OK+CO+ Nof	20 ton/ha CCM before planting; 500 kg/ha OK before planting,30 kg/ha CO every week; 30 kg/ha Nof every week.
	Control	Application such as first year

Table 3. Effect of fertilizers applied first year on yield and some yield parameters.

Fertilizers	Marketable yield			Extra class Yield	
	(t/ha)	Fruits/plant	Fruit weight (g)	(t/ha)	Fruits/plant
OK	114.40 ^{b1}	37.18 ^b	123.84 ^{ns}	78.24 ^b	22.23 ^{ns}
CO	115.80 ^b	37.54 ^b	123.37	80.28 ^b	23.65
Nof	114.92 ^b	37.37 ^b	123.40	77.60 ^b	22.08
CPM	128.12 ^a	41.13 ^a	127.68	95.10 ^a	27.82
CCM	122.92 ^a	39.12 ^{ab}	126.24	89.52 ^a	24.18
Control	115.24 ^b	38.12 ^b	123.88	86.18 ^{ab}	23.45

⁽¹⁾Different letters represent significant differences according to least significant difference ($P \leq 0.05$). ^{ns}: Not significant.

2007 experiment

Based on the results of first year data, different organic fertilizer combinations and doses were used in 2007.

Marketable yield

In 2007, the highest marketable yield was achieved from F1 and control fertilizer treatments with 121.86 and 120.72 t/ha respectively and the difference between these two treatments was not significant. However the marketable yield was significantly different between F1 and F2 fertilizer treatments ($P \leq 0.05$). The results also showed that marketable yield was affected by the cultivars what ever the fertilizer treatments. Maya F₁

cultivar had significantly higher marketable yield than the Yankı F₁ and Alida F₁ cultivars ($P \leq 0.05$).

Unmarketable yield

The highest unmarketable yield was achieved from control and F1 fertilizer treatment with 22.43 and 20.53 t/ha respectively. Among the cultivars tested, the highest unmarketable yield was obtained from Yankı F₁ (Table 4).

Extra class yield components

The results showed that extra class yields, fruit numbers and fruit weights were not significantly different among

Table 4. Effect of fertilizers applied in second year on yield and quality of three tomato varieties.

Varieties	F1	F2	Control	Mean	F1	F2	Control	Mean
Marketable yield (t/ha)					Unmarketable yield (t/ha)			
Maya F ₁	127.27	126.62	128.30	127.40 ^a	18.49	16.93	22.03	19.15 ^b
Yankı F ₁	117.65	114.45	119.08	117.06 ^b	27.91	27.21	29.33	28.15 ^a
Alida F ₁	117.25	110.86	118.19	115.43 ^b	15.18	12.72	15.93	14.61 ^b
Mean	120.72 ^{a1}	117.31 ^b	121.86 ^a		20.53 ^{ab}	18.95 ^b	22.43 ^a	
Extra class yield (t/ha)					Early yield (t/ha)			
Maya F ₁	107.64	108.44	110.45	108.84 ^a	82.47	83.47	88.48	84.81 ^{ns}
Yankı F ₁	103.21	93.05	106.27	100.84 ^b	80.58	75.16	85.41	80.38
Alida F ₁	95.32	98.14	100.32	97.93 ^b	83.79	82.71	84.54	83.68
Mean	102.06 ^{ns}	99.88	105.68		82.28 ^b	80.45 ^b	86.14 ^a	
Mean fruit weight (g)					Extra class fruit weight (g)			
Maya F ₁	153.91	159.85	154.40	156.06 ^{ns}	166.86	172.90	170.12	169.96 ^{ns}
Yankı F ₁	159.29	153.42	158.81	157.17	169.45	172.60	171.65	171.23
Alida F ₁	157.67	141.34	152.00	150.34	167.41	170.22	167.06	168.23
Mean	156.96 ^{ns}	151.54	155.07		167.91 ^{ns}	171.90	169.61	
Marketable fruit number (fruit/plant)					Extra class fruit number (fruit/plant)			
Maya F ₁	32.16	32.22	32.43	32.27 ^{ns}	24.97	25.04	25.25	25.09 ^{ns}
Yankı F ₁	30.67	31.12	30.69	30.83	25.16	24.08	24.17	24.47
Alida F ₁	30.95	30.68	30.85	30.83	24.78	25.11	24.83	24.91
Mean	31.26 ^{ns}	31.34	31.32		24.97 ^{ns}	24.74	24.75	
Cracking (%)								
Maya F ₁	2.88	2.39	2.53	2.60 ^a				
Yankı F ₁	0.66	0.89	0.45	0.67 ^c				
Alida F ₁	2.05	1.45	1.26	1.59 ^b				
Mean	1.86 ^a	1.58 ^{ab}	1.41 ^b					

⁽¹⁾Different letters represent significant differences according to least significant difference ($P \leq 0.05$). ^{ns}: Not significant.

cultivars and also among fertilizer treatments. However, the highest extra class yield was obtained in cultivar Maya F₁ (108.84 t/ha) (Table 4).

Early yield

The early yield was significantly affected by the different fertilizer treatments. Early yield was higher in inorganic fertilizer treatment with average yield of 86.14 t/ha. There was significant difference between early yield of organic fertilizer and inorganic fertilizer treatments ($P \leq 0.05$). The results showed that early yields were not significantly different among cultivars (Table 4).

Marketable fruit number

The marketable fruit number was similar among the treatments. The number of marketable fruits among the

cultivars followed a similar pattern as the fertilizer treatments (Table 4). The fruit number per plant varied from 31.26 to 31.34 in fertilizer treatments; and varied from 30.83 to 32.27 with in cultivars.

Cracking

Depending on the fertilizer treatments various degrees of cracking were observed on tomato fruits. While the highest rate of fruit cracking was obtained in F1 fertilizer treatment (1.86%), the cracking rate was lower in inorganic fertilizer treatment (1.41%) and the difference between these two treatments was significant ($P \leq 0.05$) (Table 4).

DISCUSSION

In the first year of experiment, among the organic fertilizers

higher yields were obtained from CPM and CCM treatments. The results also showed that these two fertilizer treatments provided better yield than the chemical fertilizers. As it was shown in Table 1 mineral contents of the CPM and CCM were as rich as chemical fertilizers. Hence CPM and CCM treatments showed better performance than the other fertilizers probably they contributed to a better and more balanced nutrient supply, matching well the nutrient requirements of tomato (Martini et al., 2004; Adekiya and Agbede, 2009; Parray et al., 2007). The yields of chemical fertilizer, OK, CO and Nof treatments were similar. The similarity of yield among these treatments can be attributed to the nutritional contents of them. As a matter of fact in conventional processing tomato production OK, CO and Nof have been used along with inorganic fertilizers in Turkey.

In second year of the experiment the yield of F1 fertilizer treatment were satisfactory and even comparable to that of inorganic fertilizer treatment. The results obtained were in agreement with those of Roberts et al. (2007), Heeb et al. (2005a), Heeb et al. (2005b) and Moccia et al. (2006) who reported that the application of cattle manure alone or in combination with other organic fertilizers increases organic tomato yield comparable to that of inorganic fertilizers. Additionally, Hellemi and Azarovit (2002), reported that application of composted cattle manure about 30 to 40 t/ha along with inorganic fertilizers was required to achieve higher yield in conventional tomato production.

The common sense in organic crop production system is that the yields are often lower compared to conventional production (Mäder et al., 2002; Dumas et al., 2003). The effect of organic nutrient sources depends on management practices such as combination used, application rate, application time, and methods of incorporation. So that a combination of organic sources can be considered to achieve a better and balanced nutrient supply. Furthermore, composts incorporated into soil or planting mixes can provide effective biological control of diseases caused by soilborne plant pathogens as well as foliar pathogens (Chellemi and Lazarovits, 2002; Bulluck and Ristaino, 2002; Abbasi et al., 2002). Therefore, balanced nutrient content of the composted manures or organic fertilizers and improvement of plant health by using compost or compost products can eliminate the yield reduction in organic tomato production as it is shown in the present study.

One of the main physiological disorder in tomato is fruit cracking which is generally controlled by genetical factors. Furthermore, it was reported that several other factors such as ecological conditions and production practices were effective on cracking rates of tomato fruits (Ohta et al., 1998; Suzuki and Yanase, 2005; Dorias et al., 2001; Kennely, 2009; Masarirambi et al, 2009; Huang and Snapp, 2004). The fruit cracking was higher in organic fertilizer treatments than the inorganic fertilizer at the present study. The stimulation of plant growth by

organic fertilizers and calcium deficiency of tomato fruits might have been responsible for the higher fruit cracking in organic fertilizer treatments.

An earliness and in connection with this characteristic early yields mainly controlled by genetical factors in tomato (Banerjee and Kalloo, 2006). The early yields of tomato cultivars tested in this study were not significantly different from each other, because none of the cultivar tested at the present study was early maturing cultivar. On the other hand the early yields in organic fertilizer treatments were lower than that of inorganic fertilizers. Stimulation of vigorous vegetative growth of tomato plant at early stage of development by organic fertilizers might have been responsible for lower early yields. The vigorous vegetative growth delays flowering as well as earliness.

Conclusion

In conclusion, this work showed that, satisfactory tomato yield and quality, comparable to those usually found for conventionally grown tomato, could be obtained in organic production systems using adequate combinations and rates of organic nutrient sources. Based on the data and method described earlier, use of fertilizer combinations CPM +CO+Nof could be recommended for organic tomato production in Tokat province of Turkey.

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