INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
09–067/DMZ/2009/11–5–626–630
http://www.fspublishers.org

Full Length Article

Response of Yield and Yield Components of Tomato (*Lycopersicon esculentum*) to Different Tillage Methods

MAJID RASHIDI[1], MOHAMMAD GHOLAMI AND BORZOO GHAREEI KHABBAZ†
Department of Agricultural Machinery, Faculty of Agriculture, Islamic Azad University, Takestan Branch, Iran
†*Department of Agricultural Machinery, Faculty of Engineering and Surveying, University of Southern Queensland, Australia*
[1]Corresponding author's e-mails: majidrashidi81@yahoo.com; m.rashidi@aeri.ir

ABSTRACT

A field experiment was conducted at the Research Site of Varamin Agricultural Research Center, Varamin, Iran on the sandy loam soils to study the response of tomato (*Lycopersicon esculentum*) to different tillage methods during 2007 and 2008 growing seasons. Tillage treatments in the study included were conventional tillage (CT; moldboard plowing + two passes of disk harrowing), minimum tillage (MT; one pass of disk harrowing) and no-tillage (NT). Yield, yield components (plant population density, PPD; number of fruits per plant, NFPP; fruit weight, FW; fruit length, FL; fruit diameter, FD) and fruit quality parameter (total soluble solids, TSS) were determined for all treatments. Results indicated that tillage methods significantly ($P \leq 0.05$) influenced the yield, yield components and TSS. Results also showed that PPD and NFPP were the most important yield components explaining yield difference under the different tillage methods. The maximum PPD (10025 plants ha^{-1}), NFPP (19.1) and as a result yield (12.2 t ha^{-1}) were observed with the CT, while maximum values of FW (71.2 g), FL (70.0 mm), FD (59.2 mm) and TSS (7.27%) were noted NT plots. On the other hand, minimum PPD (5117 plants ha^{-1}), NFPP (10.2) and hence yield (3.70 t ha^{-1}) were obtained with NT, while the minimum values of FW (63.6 g), FL (61.0 mm), FD (53.6 mm) and TSS (5.81%) were noted in case of the CT treatment. Therefore, one pass of moldboard plow followed by two passes of disk harrow was found to be more appropriate and profitable tillage method in improving yield of tomato in the arid lands of Iran.

Key Words: Conventional tillage; Conservation tillage; Minimum tillage; No tillage; Tomato; Yield; Arid lands; Iran

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is one of the most important vegetable crops of Iran and is well adapted to its soil and climatic conditions. Tomato ranks first in cultivated area and production among all other vegetables in Iran (Iranian Ministry of Agriculture, Statistical Yearbook, 2006). According to Agricultural Ministry of Iran the average national production of tomato for the last two years was 4.4 million tones. Although the use of improved varieties and fertilizers has increased tomato production to much extent the full potential of crop production has not yet been achieved when compared to progressive countries (Iranian Ministry of Agriculture, Statistical Yearbook, 2006).

Soil tillage is one of the very important factors that affect soil physical properties and yield (Keshavarzpour & Rashidi, 2008; Rashidi & Keshavarzpour, 2008). Khurshid *et al.* (2006) reported that among the crop production factors, tillage contributes up to 20%. Tillage method affects the sustainable use of soil resources through its influence on soil properties i.e., proper tillage practices can improve soil related constrains, while improper tillage may cause a range of undesirable processes such as destruction of soil structure, accelerated erosion, depletion of organic matter and fertility and disruption in cycles of water, organic carbon and plant nutrients (Lal, 1993). Use of excessive and un-necessary tillage operations is harmful to soil. Therefore, currently there is a significant interest and emphasis on the shift to the conservation tillage and no-tillage methods for the purpose of controlling soil erosion (Iqbal *et al.*, 2005).

Most of the tomato area in Iran is under conventional tillage (CT; Iranian Ministry of Agriculture, Statistical Yearbook, 2006). CT practices modify soil structure by changing its physical properties such as soil bulk density, soil penetration resistance and soil moisture content (Keshavarzpour & Rashidi, 2008; Rashidi *et al.*, 2008). Annual disturbance and pulverizing caused by CT produce a finer and loose soil structure as compared to conservation and NT methods, which leave soil intact (Rashidi & Keshavarzpour, 2007; Rashidi *et al.*, 2008). This difference results in change number, shape, continuity and size distribution of the pores network, which controls the ability of soil to store and transmit air, water and agricultural chemicals. This also improves porosity and water holding capacity of the soil. This all leads to a favorable

To cite this paper: Rashidi, M., M. Gholami and B.G. Khabbaz, 2009. Response of yield and yield components of tomato (*Lycopersicon esculentum*) to different tillage methods. *Int. J. Agric. Biol.*, 11: 626–630

environment for crop growth and nutrient use (Khan *et al.*, 2001; Khurshid *et al.*, 2006).

On the other hand, conservation tillage methods often result in decreased pore space (Hill, 1990), increased soil strength (Bauder *et al.*, 1981) and stable aggregates (Horne *et al.*, 1992). The pore network in conservationally tilled soil is usually more continuous, because of earthworms, root channels and vertical cracks (Cannel, 1985). Therefore, conservation tillage may reduce disruption of continuous pores. Reddy *et al.* (2007) quantified the amount of carbon dioxide (CO_2) released from soil as a result of different tillage methods. They observed 37% higher CO_2 efflux from conventionally tilled soils compared to no-till soils, which represents higher carbon sequestration in no-till soils. However, the results of conservation tillage and NT methods are contradictory (Iqbal *et al.*, 2005). Conservation tillage and NT methods in arid lands of Iran had an adverse effect on yields of some crops (Hemmat & Taki, 2001). Conversely, while comparing CT method to conservation tillage and NT methods Chaudhary *et al.* (1992) concluded that higher moisture preservation and 13% more income were obtained in case of NT.

Although considerable amount of research has been done on many crops, information on response of tomato to conservation tillage and NT methods is meager. At this time, a wide range of tillage methods is being used in Iran without evaluating their effects on yield and yield components of many crops including tomato. Therefore, the present investigation was planned to determine the response of yield and yield components of tomato to different tillage methods in the arid lands of Iran.

MATERIALS AND METHODS

Experimental site. The experiment was carried out for two consecutive growing seasons (2007 & 2008) at the Research Site of Varamin Agricultural Research Center, Varamin, Iran. The site is located at latitude of 35° 19' N and longitude of 51° 39' E and is 1000 m above mean sea level in arid climate in the center of Iran, where the summers are dry and hot, while the winters are cool. The soil of the experimental site was a fine, mixed, thermic, Typic Haplocambids sand loam soil. Details of soil physical and chemical properties of the experimental site are given in Table I.

Soil sampling and analysis. In order to determine soil physical and chemical properties of the experimental site, a composite soil sample was collected from 18 points in the entire plot before treatment imposition in 2007. Soil sample was analyzed in the laboratory for N, P, K, Fe, Zn, Cu, Mn, B, EC, pH, organic carbon, particle size distribution and dry bulk density. Total N (%) was determined by the macro-Kjeldahl method (Bremner, 1982). Available P (ppm) was found using Bray II method according to Olsen (1982). The exchangeable cations were calculated by the method described by Thomas (1982). Soil EC and soil pH values were obtained by using a HI9813-5 portable pH/EC/TDS/°C meter (2002, HANNA instruments, Romania). Soil organic carbon was determined by Walkley-Black procedure (Nelson & Sommers, 1982). Particle size distribution was determined by hydrometer method (Gee & Bauder, 1986). Dry bulk density was found by the core method (Blake & Hartge, 1986).

Field methods. The experiments were laid out in a randomized complete block design (RCBD). Tillage treatments included CT, minimum tillage (MT) and NT and they were replicated three times. CT included one pass of moldboard plow to a depth of 15 cm and was followed by two passes of disk harrowing. MT included only one pass of disk harrowing. NT included zero tillage activity. The treatments were carried out on the same plots in the 2007 and 2008 growing seasons. The size of each plot was 10.0 m long and 6.0 m wide. A buffer zone of 5.0 m spacing was provided between plots. There were two furrows in each plot (even in no-till plots). The furrows had 10.0 m long, 75 cm wide and 50 cm depth. In both growing seasons, one of the most commercial varieties of tomato cv. early urbana was transplanted manually on both sides of each furrow with 50 cm plant to plant spacing (totally there were four rows per plot). Before transplanting, recommended levels of N (350 kg ha^{-1}), P (100 kg ha^{-1}) and K (50 kg ha^{-1}) were used as Urea, TSP (triple super phosphate) and SOP (sulphate of potassium), respectively. They were incorporated in the CT and MT and surface applied in the NT. Trifluralin (0.75 L ha^{-1}) was also applied for weed control before tomato transplanting. Tomato was transplanted on 5th May when the soil was well irrigated in all treatments. During the growing season, the insecticides and fungicides were applied according to general local practices and recommendations. All other necessary operations except those under study were kept normal and uniform for all the treatments.

Weather parameters. The mean monthly rainfall and temperature data of the experimental site for 2007 and 2008 are given in Fig. 1.

Observation and data collection. Tomatoes were harvested three times (23 July, 12 August & 31 August, respectively) and standard procedures were adopted for recording the data on yield and yield components. Yield, plant population density (PPD) and number of fruits per plant (NFPP) were determined by counting plants and harvesting fruits of the two middle rows of each plot (Srivastava *et al.*, 1994). Other parameters i.e., fruit weight (FW), fruit length (FL), fruit diameter (FD) and total soluble solids (TSS) were determined from the 20 samples taken randomly from harvested fruits of the two middle rows of each plot (Doss *et al.*, 1980; Jain *et al.*, 2000). The TSS of tomatoes was measured using an ATC-1E hand-held refractometer (ATAGO, Japan, 2005) at temperature of 20°C.

Data analysis. The Data were subjected to ANOVA using statistical software, SPSS 12.0 for Windows (SPSS Inc., 233 S Wacker Drive, Chicago, IL, USA). Means were separated

by Duncan's Multiple Range Test (DMRT) at $P \leq 0.05$ (Steel & Torrie, 1984).

RESULTS

Yield and yield components of tomato were significantly influenced by tillage methods. Among the three different tillage methods, the CT method recorded significantly higher yield (12.2 t ha^{-1}) compared to NT (3.7 t ha^{-1}) and MT (6.2 t ha^{-1}) methods, respectively. Between the two conservation tillage methods, the MT method recorded significantly higher yield (67%) than NT method. A similar trend was also observed in case of PPD and NFPP. Significantly higher PPD and NFPP were observed in the CT plots (10025 plants ha^{-1} & 19.1, respectively) compared to MT (6908 plants ha^{-1} & 13.2, respectively) and NT (5117 plants ha^{-1} & 10.2, respectively) plots (Table II).

In contract to the above trend, NT and MT methods recorded significantly higher FW, FL, FD and TSS compared to the CT method. Between conservation tillage methods, the NT method recorded higher values for the above parameters. Values of FW, FL and FD were 12, 15 and 10%, respectively higher in NT plots compared to that of the CT plots. The quality parameter of tomato fruits, TSS was significantly higher in NT plots (7.27%) compared to that of the CT (5.81%) and MT (6.31%) plots (Table II).

DISCUSSION

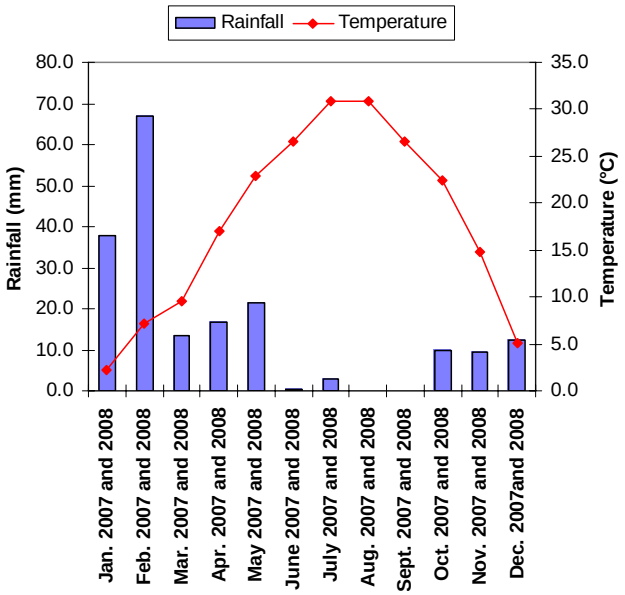
In this study, the salient components of yield such as PPD, NFPP, FW, FL, FD and a fruit quality parameter i.e., TSS were studied to analyze the effect of different tillage methods on growth and yield of tomato. The statistical results of the study indicated that tillage method significantly affected yield, PPD, NFPP, FW, FL, FD and TSS during the study years. Results also showed that tillage practices were beneficial in improving the growth and yield of tomato (Table II).

The maximum value of PPD (10025 plants ha^{-1}) and NFPP (19.1) was observed in case of the CT treatment, while maximum value of FW (71.2 g), FL (70.0 mm), FD (59.2 mm) and TSS (7.27%) was noted in case of NT treatment. As PPD and NFPP were the most important yield components explaining yield of tomato under different tillage methods, the maximum value of yield (12.2 t ha^{-1}) was observed in case of the CT treatment (Table II). These results are in agreement with those of Khan *et al.* (1999), Khan *et al.* (2001), Iqbal *et al.* (2005), Khurshid *et al.* (2006), Rashidi and Keshavarzpour (2007), Keshavarzpour and Rashidi (2008), Rashidi and Keshavarzpour (2008) and Rashidi *et al.* (2008) who concluded that CT can be associated with reduced soil penetration resistance, reduced soil bulk density, increased soil moisture preservation, improved soil structure, enhanced root-soil contact and better weed growth suppressing, which favorably affect root development, plant growth and plant population density, resulting in increased crop yield.

Table I. Soil physical and chemical properties of the experimental site (0-30 cm depth)

Soil characteristics	Values
Texture	Sand loam
Sand (%)	54.0
Silt (%)	28.0
Clay (%)	18.0
Bulk density (Mg m^{-3})	1.51
EC (dS m^{-1})	2.90
pH	8.00
Organic carbon (%)	0.50
Total N (%)	0.06
Available P (ppm)	9.20
Available K (ppm)	272
Available Fe (ppm)	2.82
Available Zn (ppm)	2.06
Available Cu (ppm)	0.90
Available Mn (ppm)	8.20
Available B (ppm)	2.06

Fig. 1. Mean monthly rainfall and temperature during crop growth, 2007 and 2008



On the other hand, the minimum value of PPD (5117 plants ha^{-1}) and NFPP (10.2) was obtained in case of NT treatment, while the minimum value of FW (63.6 g), FL (61.0 mm), FD (53.6 mm) and TSS (5.81%) were noted in case of the CT treatment. In view of the fact that PPD and NFPP were the most important yield components explaining yield of tomato under different tillage methods, the minimum value of yield (3.70 t ha^{-1}) was obtained in case of NT treatment (Table II). These results are in agreement with those of Bauder *et al.* (1981), Hill (1990), Horne *et al.* (1992), who concluded that NT and conservation tillage methods can be associated with decreased pore space, increased soil penetration resistance, increased soil bulk density, decreased soil moisture conservation, which adversely affect root development, plant growth, plant

Table II. Effect of different tillage treatments on yield and yield components of tomato (average of 2007 & 2008)

Treatments	Yield (t ha^{-1})	PPD (plant ha^{-1})	NFPP	FW (g)	FL (mm)	FD (mm)	TSS (%)
Conventional tillage (CT)	12.2 a	10025 a	19.1 a	63.6 c	61.0 c	53.6 c	5.81 c
Minimum tillage (MT)	6.19 b	6908 b	13.2 b	67.6 b	64.8 b	57.6 b	6.31 b
No-tillage (NT)	3.70 c	5117 c	10.2 c	71.2 a	70.0 a	59.2 a	7.27 a
$LSD_{5\%}$	0.160	244.9	0.373	0.742	1.260	0.991	0.453

Means in the same column with different letters differ significantly at 0.05 probability level according to DMRT
(PPD: plant population density, NFPP: number of fruits per plant, FW: fruit weight, FL: fruit length, FD: fruit diameter, TSS: total soluble solids)

population density and consequently yield. These results are also in line with the results reported by Iqbal *et al.* (2005) that NT method cannot compensate the adverse effect of fine texture, very low organic matter and an overall initial weak structure of the soil (Hemmat & Taki, 2001; Keshavarzpour & Rashidi, 2008). Reddy and Reddy (2008) concluded that NT needs extra nutrients in the form of crop residue to give similar yields to CT. They observed 18% higher yields in CT compared to NT with similar quantity of nutrients. Conversely, they observed 21% higher yields in NT plots compared to CT when extra crop residue was included in the form of winter cover crop. Hence, more studies are needed to find the response of tomato to NT along with higher nutrient dosage and residue cover.

CONCLUSION

Among three methods of tillage imposed, the CT method was found to be better over the MT and NT methods in achieving higher yield of tomato through improving PPD and NFPP. Reduced soil penetration resistance and soil bulk density, increased soil moisture preservation, root-soil contact and weed growth suppressing might have helped in retaining good PPD and NFPP resulting in higher yield in conventionally tilled plots. One pass of moldboard plow followed by two passes of disk harrow can be more appropriate tillage method in improving yield of tomato in the arid lands of Iran. Further studies are needed to find the beneficial effects of NT on soil quality and yield when it is supplemented with extra nutrients or crop residue.

Acknowledgement. Thanks to Engr. Mohammad-Reza Imani and Engr. Mohsen Seilsepour for statistical expertise on several occasions and Engr. Fereydoun Keshavarzpour for technical help and instrumentation. The financial support provided by the Agricultural Extension, Education and Research Organization of Iran under research award number 2-109-220000-14-0000-86008 is gratefully acknowledged.

REFERENCES

Bauder, J.W., G.W. Randall and J.B. Swan, 1981. Effects of four continue tillage systems on mechanical impedance of a clay-loam soil. *Soil Sci. Soc. American J.*, 45: 802–806

Bremner, J.M., 1982. Total nitrogen. *In*: Page, A.L., R.H. Miller and D.R. Keeny (eds.), *Methods of Soil Analysis*, Part 2, 2nd edition, pp: 915–928. Agronomy Monograph No. 9. ASA and SSSA, Madison, WI

Blake, G.R. and K.H. Hartge, 1986. Bulk density. *In*: Klute, A. (ed.), *Methods of Soil Analysis*, Part 1, 2nd edition, pp: 365–375. Agronomy Monograph No. 9. ASA and SSSA, Madison, WI

Cannel, R.Q., 1985. Reduced tillage in north-west Europe-a review. *Soil Tillage Res.*, 5: 129–177

Chaudhary, A.D., M. Javed, M.A. Rana, A. Sarwar and Q. Zaman, 1992. Comparative performance of direct drilling and conventional tillage practices under rice-wheat rotation system. *Pakistan J. Agric. Sci.*, 29: 5–8

Doss, B.D., J.L. Turner and L.E. Evans, 1980. Irrigation methods and in row chiseling for tomato production. *J. American Soc. Hortic. Sci.*, 105: 611–614

Gee, G.W. and J.W. Bauder, 1986. Particle size analysis. *In*: Klute, A. (ed.), *Methods of Soil Analysis*, Part 1, 2nd edition, pp: 383–411. Agronomy Monograph No. 9. ASA and SSSA, Madison, WI

Hemmat, A. and D. Taki, 2001. Grain yield of irrigated wheat as affected by stubble tillage management and seeding rates in central Iran. *Soil Tillage Res.*, 63: 57–64

Hill, R.L., 1990. Long-term conventional and no-tillage effects on selected soil physical properties. *Soil Sci. Soc. American J.*, 54: 161–166

Horne, D.J., C.W. Ross and K.A. Hughes, 1992. Ten years of maize/oats rotation under three tillage systems on a silt-loam soil in New Zealand. 1. A comparison of some soil properties. *Soil Tillage Res.*, 22: 131–143

Iqbal, M., A.U. Hassan, A. Ali and M. Rizwanullah, 2005. Residual effect of tillage and farm manure on some soil physical properties and growth of wheat (*Triticum aestivum* L.). *Int. J. Agric. Biol.*, 7: 54–57

Jain, N., H.S. Chauhan, P.K. Singh and K.N. Shukla, 2000. Response of tomato under drip irrigation and plastic mulching. *In: Proc. 6th Int. Micro-irrigation Congress, Micro-irrigation Technology for Developing Agriculture, 22-27 October 2000*. South Africa

Keshavarzpour, F. and M. Rashidi, 2008. Effect of different tillage methods on soil physical properties and crop yield of watermelon (*Citrullus vulgaris*). *World Appl. Sci. J.*, 3: 359–364

Khan, F.U.H., A.R. Tahir and I.J. Yule, 1999. Impact of different tillage practices and temporal factor on soil moisture content and soil bulk density. *Int. J. Agric. Biol.*, 1: 163–166

Khan, F.U.H., A.R. Tahir and I.J. Yule, 2001. Intrinsic implication of different tillage practices on soil penetration resistance and crop growth. *Int. J. Agric. Biol.*, 3: 23–26

Khurshid, K., M. Iqbal, M.S. Arif and A. Nawaz, 2006. Effect of tillage and mulch on soil physical properties and growth of maize. *Int. J. Agric. Biol.*, 8: 593–596

Lal, R., 1993. Tillage effects on soil degradation, soil resilience, soil quality and sustainability. *Soil Tillage Res.*, 51: 61–70

Nelson, D.W. and L.E. Sommers, 1982. Total carbon, organic carbon and organic matter. *In*: Page, A.L., R.H. Miller and D.R. Keeny (eds.), *Methods of Soil Analysis*, Part 2, 2nd edition, pp: 539–579. Agronomy Monograph No. 9. ASA and SSSA, Madison, Wisconsin

Olsen, S.R., 1982. Phosphorus. *In*: Page, A.L., R.H. Miller and D.R. Keeny (eds.), *Methods of Soil Analysis*, Part 2, 2nd edition, pp: 403–430. Agronomy Monograph No. 9. ASA and SSSA, Madison, Wisconsin

Rashidi, M. and F. Keshavarzpour, 2007. Effect of different tillage methods on grain yield and yield components of maize (*Zea mays* L.). *Int. J. Agric. Biol.*, 9: 274–277

Rashidi, M. and F. Keshavarzpour, 2008. Effect of different tillage methods on soil physical properties and crop yield of melon (*Cucumis melo*). *American-Eurasian J. Agric. Environ. Sci.*, 3: 31–36

Rashidi, M., F. Keshavarzpour and M. Gholami. 2008. Effect of different tillage methods on yield and yield components of forage corn. *American-Eurasian J. Agric. Environ. Sci.*, 3: 347-351

Reddy, S.S., K.C. Reddy and R. Tiffany, 2007. Influence of tillage and poultry litter application on carbon dioxide efflux and carbon storage in soil under cotton production system. *Proc. of ASA-CSSA-SSSA 2007 International Meetings, New Orleans, LA, Nov 4-8, 2007*. Available online at http://a-c-s.confex.com/a-c-s/2007am/techprogram/P34934.HTM

Reddy, S.S. and K.C. Reddy, 2008. Cotton lint yield and soil quality as influenced by continuous poultry litter application for 5-yr. *Proc. of ASA-CSSA-SSSA 2008 International Meetings, Houston, TX, Oct. 5-9, 2008*. Available online at http://a-c-s.confex.com/crops/2008am/techprogram/P43784.HTM

Srivastava, P.K., M.M. Parikh, N.G. Sawani and S. Raman, 1994. Effect of drip irrigation and mulching on tomato yield. *Water Manag.*, 25: 179–184

Steel, R.G.D. and J.H. Torrie, 1984. *Principles and Procedures of Statistics: A Biometrical Approach.* McGraw Hill Book Co., Inc., New York

Thomas, G.W., 1982. Exchangeable cations. *In*: Page, A.L., R.H. Miller and D.R. Keeny (eds.), *Methods of Soil Analysis*, Part 2, 2nd edition, pp: 159–165. Agronomy Monograph No. 9. ASA and SSSA, Madison, Wisconsin

(Received 23 February 2009; Accepted 14 April 2009)