Journal of Agricultural Machinery
Vol. 10, No. 1, Spring- Summer 2020, p. 103-114

نشریه ماشین‌های کشاورزی
جلد ۱۰، شماره ۱، نیمسال اول ۱۳۹۹، ص ۱۱۴-۱۰۳

Cotton Yield and Water Productivity Affected by Conservation Tillage and Irrigation Methods in Cotton-Wheat Rotation

S. Afzalinia[1*], A. Ziaee[2]

Received: 26-10-2018
Accepted: 10-03-2019

Abstract

In this study, the effect of conservation tillage and irrigation methods on the soil properties, cotton yield, and water productivity was evaluated in a wheat-cotton cropping system in the form of a split-plot experimental design. The main plots were irrigation using the three methods including surface irrigation, drip tape irrigation, and sprinkler irrigation. Tillage methods including zero tillage, reduced tillage, and conventional tillage were considered as subplots in this research. Results showed that tillage methods had no significant effect on cotton yield; whereas, the cotton yield was significantly affected by irrigation methods ($p<0.05$). Tape and sprinkler irrigation methods saved water compared to surface irrigation for 51% and 28%, respectively. The maximum water productivity (0.324 kg m^{-3}) was obtained from the tape irrigation and the minimum water productivity (0.146 kg m^{-3}) was related to surface irrigation. Results also indicated that irrigation and tillage methods had a significant effect on the soil bulk density and infiltration rate so that drip tape irrigation and conventional tillage had the highest infiltration rates, and tape irrigation and reduced tillage had the highest soil bulk density.

Keywords: Cotton, Soil bulk density, Soil infiltration rate, Tillage methods, Water consumption, Water productivity

Introduction

Fars province with 15831 ha of planting area, 50976 tons of production, and 3220 kg ha^{-1} of yield has the second place in producing cotton in Iran (Agricultural Statistics, 2018). Cotton is planted in this province mostly using conventional tillage methods. Using conservation tillage methods in planting cotton has been started recently. Conservation tillage improves soil and water resources (Freebairn *et al.*, 1986), saves energy and time (Afzalinia *et al.*, 2009), and reduces the costs of agricultural products (Erenstein and Laxmi, 2008). The effects of conservation tillage on cotton yield have been evaluated in several studies so far. Conservation tillage under both irrigated and dryland conditions increased cotton profitability compared to the conventional tillage system (Keeling *et al.*, 1989). Strip tillage increased cotton yield and economic return compared to the no-till system (Schomberg *et al.*, 2006). Using crop residue as a soil covering mulch can play a significant role in no-till system success in cotton growing. Results of research conducted in Cameron showed that no-tillage along with crop residue mulch increased cotton yield compared to the conventional tillage and no-till without mulch (Naudin *et al.*, 2010).

Conservation tillage performance may be affected by the irrigation method used on the farm. Conservation tillage had higher water use efficiency in wheat and corn production under the tape irrigation method compared to surface and sprinkler irrigation (Dehghanian and Afzalinia, 2012). Wheat productivity was higher under the flat no-till method compared to the furrow irrigated raised bed and conventional till flat planting in the maize-wheat cropping system (Jat *et al.*, 2005). Conservation tillage reduced water consumption and increased wheat yield for 12% (Freebairn *et al.*, 1986). Soil hydraulic conductivity, soil water absorption, and soil

1- Department of Agricultural Engineering Research, Fars Research and Education Center for Agriculture and Natural Resources, AREEO, Shiraz, Iran
2- Department of Agricultural Engineering Research, Fars Research and Education Center for Agriculture and Natural Resources, Darab Station, AREEO, Darab, Iran
(*- Corresponding Author Email: ja925@mail.usask.ca)
DOI: 10.22067/jam.v10i1.76229

micro-organisms activity were higher in the no-till system compared to the conventional tillage (McGarry *et al.,* 2000). Sprinkler irrigation reduced water consumption compared to surface irrigation for 30% (Haq, 1990). Tape irrigation increased cotton yield compared to the furrow and sprinkler irrigation for 21 and 30%, respectively and had the maximum water use efficiency (4.87 kg ha^{-1} mm^{-1}) compared to these irrigation methods (Cetin and Bilgel, 2002).

No-tillage and permanent bed planting reduced the maize-wheat-mungbean cropping system irrigation water requirement and increased grain yield, biomass yield, and water use efficiency in this cropping system compared to the conventional tillage (Parihar *et al.,* 2017). The zero tillage method decreased evaporation from the topsoil, soil temperature, and corn yield and increased water retention during the critical growth stage of corn, soil bulk density, and soil penetration resistance (Fabrizzi *et al.*, 2005; De Vita *et al.*, 2007). The lower cotton yield and water productivity were obtained from the minimum tillage method compared to the conventional tillage (Jalota *et al.*, 2008). Conservation tillage methods (no-till and minimum tillage) provided higher soil water content, cotton root growth, and cotton yield compared to the conventional tillage (Karamanos *et al.*, 2004). Zero tillage saved soil water content for 23.4% compared to the conventional tillage in dryland vetch-wheat cropping system (Eskandari and Feiziasl, 2017). Overall, researches show that conservation tillage methods increase moisture retention in the soil and decrease water consumption. On the other hand, results show that pressurized irrigation methods, in contrast to surface irrigation methods, significantly reduce water consumption and increase water productivity. The issue that has not been adequately investigated is the effect of interaction between conservation tillage and irrigation methods on water consumption and water productivity. Therefore, the objective of this study was to simultaneously evaluate the effect of conservation tillage and irrigation methods on the cotton yield and water productivity.

Materials and Methods

In order to evaluate the effect of tillage and irrigation methods on the soil bulk density, soil infiltration rate, cotton yield, and cotton water productivity, this research was conducted in Darab region of Fars province (Southern Iran, 28°29′E, 54°57′N, 1080 m above sea level) from 2010 to 2012. Details of the region weather condition are presented in Table 1. The research was conducted based on split-plot experimental design with nine treatments and three replications. The main plots in this research were irrigation methods including 1) surface irrigation; 2) drip tape irrigation; and 3) sprinkler irrigation. Surface irrigation was applied using a gated pipe with a gate space of 75 cm. Drip tape with dripper space of 20 cm and a row space of 75 cm was used in drip irrigation. Traveling gun with Pirot ZK30 sprinkler, operation pressure of 3 bars, the flow rate of 0.7 litter per second, jet length of 19 m, and arrangement of 20 m by 20 m were used in sprinkler irrigation. Tillage methods including zero tillage (ZT), reduced tillage (RT), and conventional tillage (CT) were considered as subplots of this research. Wheat standing residues were retained in the plots and loose residues were taken out of the plots. In the conventional tillage method, primary tillage was performed using a moldboard plow and secondary tillage operation was done using a disk harrow and land leveler then crop seed was planted using seed planter. Seedbed was prepared in the reduced tillage method using a tine and disc cultivator which was able to complete the primary and secondary tillage operations simultaneously then crop seed was planted using seed planter. Cotton and wheat seeds were directly planted using direct planter without any seedbed preparation in the zero-tillage method. The rotation started with cotton and ended with wheat. A local cotton variety (Bakhtegan) was planted with the seed rate of 25 kg ha^{-1}, the row space of 75 cm, and within row space of 20 cm in 20 by 6 m plots in early July and harvested in early December. Wheat variety of Chamran was planted with the seed rate of 250 kg ha^{-1} and the row space of 17 cm in early December and harvested in late May. Irrigation scheduling was programed every 8, 4, and 2 days for surface, sprinkler, and drip irrigation, respectively based on actual evapotranspiration from the crop, soil water content, and water discharge from the soil. A combination of mechanical and chemical weed control methods was applied to all the treatments identically. Nitrogen, potassium, and phosphorus were applied identically to all the treatments as fertilizers based on the soil elements analysis. Specifications of the soil in which the experiment was performed are presented in Table 2.

Table 1- Climate condition information of the study area

Month	Growing season							
	2010-2011				2011-2012			
	Rainfall (mm)	Evaporation (mm)	Average relative humidity (%)	Average temperature (°C)	Rainfall (mm)	Evaporation (mm)	Average relative humidity (%)	Average temperature (°C)
April	9.1	155.1	45	19.0	13.8	134.7	49	18.6
May	0.0	254.8	31	26.0	6.3	243.9	34	25.4
Jun	0.0	325.5	23	31.5	0.4	368.7	34	30.8
July	0.0	354.2	23	33.7	0..0	364.1	37	33.4
August	3.6	372.7	23	34.1	0.0	375.8	34	33.6
September	0.0	271.3	30	29.8	0.0	274.0	29	30.4
October	0.0	194.2	29	26.0	0.1	186.8	55	24.7
November	0.0	124.9	33	18.6	3.0	115.4	64	17.7
December	0.0	76.7	32	13.2	32.3	57.0	81	11.8
January	39.3	64.9	45	10.7	22.5	60.6	76	10.8
February	210	36.1	71	9.9	62.3	58.8	79	10.2
March	14.1	73.0	55	15.1	31.7	101.8	69	13.0

Table 2- Selected properties of the soil used for the study

Soil depth (mm)	Organic carbon (OC) (%)	Electrical conductivity (EC) (dS m^{-1})	Acidity (pH)	Clay (%)	Silt (%)	Sand (%)	Soil texture
0-100	0.87	0.97	7.7	21.67	36.00	42.33	Loam
100-200	0.79	0.85	7.7	20.00	38.00	42.00	Loam

Soil infiltration rate was determined before crop harvesting each year using the double ring method (Kostiakov, 1932). Soil bulk density was also measured before crop harvesting in the first and second years of study. This parameter was determined in soil depth ranges of 0 to 100 and 100 to 200 mm using core samplers, and drying samples at 105 degrees centigrade for 24 hours in the oven. The following equation was used to calculate the soil bulk density (Black and Harte, 1986):

$$BD = \frac{W_d}{V} \qquad (1)$$

Where:
BD = soil bulk density (g cm^{-3}),
W_d = sample dry weight (g), and
V = Sample total volume (cm^3).

The cotton yield per unit area was obtained by harvesting an area of 22.5 m^2 of each plot. Water applied to each main plot was measured using a three inches water flow meter (Abfar Company, Tehran) installed on the pipe supplying water to the main plots. Water productivity was then computed using the following equation (Ali and Talukder, 2008):

$$WP = \frac{Y}{W} \qquad (2)$$

Where:
WP = water productivity (kg m^{-3}),
Y= crop yield (kg ha^{-1}), and
W = water consumption (m^3 ha^{-1}).

Data collected from the field experiments were subjected to analysis of variance

(ANOVA) at the confidence level of 95% using SAS software and Duncan's multiple range tests (P=0.05) were used to compare the treatments means.

Results and Discussion

Cotton yield

Variance analysis of cotton yield data showed that year, irrigation method, and interaction between year and irrigation had a significant effect ($p<0.05$) on the cotton yield (Table 3). Tillage methods and interaction between irrigation and tillage methods had no significant influence on the cotton yield. This indicated that the conservation tillage methods did not significantly decrease cotton yield compared to the conventional tillage.

Table 3-Variance analysis of cotton yield data

Variation resources	df	Mean square	F value
Replication	2	3364378.6	6.79^{**}
Year	1	3085968.2	6.23^{*}
Irrigation methods	2	1477009.5	2.98^{*}
Tillage methods	2	552036.8	1.11^{ns}
Year × Irrigation	2	1939510.7	3.92^{*}
Year × Tillage	2	665370.5	1.34^{ns}
Irrigation × Tillage	4	368781.1	0.82^{ns}
Year × Irrigation × Tillage	4	653449.1	1.46^{ns}
Error	28	495325.5	

^{ns}: Non-significant; *: significant at $p<0.05$; **: significant at $p<0.01$.

Means comparison of cotton yield in different irrigation methods is presented in Table 4. According to the results shown in this Table, the cotton yield was significantly higher in the second year (2915 kg ha^{-1}) compared to that of the first year (2437 kg ha^{-1}) due to more moderate climate conditions during the cotton growing season in the second year (Table 1). The maximum cotton yield (2984 kg ha^{-1}) was obtained from the sprinkler irrigation method which was significantly different from those of tape and surface irrigation. There was no significant difference between surface and drip tape irrigation from the cotton yield point of view. Sprinkler irrigation increased cotton yield compared to the surface and drip tape irrigation on average by 23.41 and 13.63%, respectively; while, Cetin and Bilgel (2002) found that drip irrigation increased cotton yield by 21 and 30% compared to the furrow and sprinkler irrigation, respectively. This discrepancy was probably because of the effects of region and climate conditions differences.

There was no significant difference between cotton yields in different tillage methods and conservation tillage methods even increased cotton yield compared to the conventional tillage method (Table 4). These results showed that conventional tillage can be easily replaced by conservation tillage methods (no-till and reduced tillage) in cotton production. These results are in good agreement with the results of research performed by Karamanos *et al.* (2004).

Water applied and water productivity

Results of comparing water applied to different irrigation methods showed that the maximum water application (average of 16483 m^3 ha^{-1}) was occurred in the surface irrigation for cotton production because of its lowest irrigation efficiency and the minimum water application (average of 8113 m^3 ha^{-1}) was related to the drip irrigation (Table 5). The sprinkler irrigation method with an average water application of 11889 m^3 ha^{-1} had the second place from the water application point of view among the irrigation methods tested. As a result, the drip and sprinkler irrigation reduced water application in cotton production compared to surface irrigation for 50% and 28%, respectively. Haq (1990) and Latif (1990) also reported that sprinkler irrigation decreased water application compared to surface irrigation.

Table 4- Means comparison of cotton yield in different treatments

Year		Cotton yield (kg ha^{-1})
First year		2437 b
Second year		2915 a
Irrigation methods		-
Drip tape		2626 b
Surface		2418 b
Sprinkler		2984 a
Tillage methods		-
Conventional tillage		2474 a
Reduced tillage		2768 a
No-tillage		2786 a
Year × Irrigation		-
First year	Drip tape	2290 b
First year	Surface	1910 c
First year	Sprinkler	3111 a
Second year	Drip tape	2962 a
Second year	Surface	2926 a
Second year	Sprinkler	2857 a

a, b, c: Averages with different letters in each column are statistically different at p<0.05.

Table 5- Water applied for cotton growing in different irrigation methods

Irrigation methods	Water applied (m^3 ha^{-1})		
	2010	2011	Average
Drip tape	8139	8087	8113
Surface	16320	16645	16483
Sprinkler	11692	12086	11889

Variance analysis of water productivity data revealed that year and irrigation methods had a significant effect on water productivity in cotton production, while tillage methods and interaction between irrigation and tillage methods had no remarkable influence on cotton water productivity (Table 6). Since water applied to the various irrigation methods was different, a significant effect of irrigation methods on water productivity was expected. On the other hand, cotton yields were not significantly different in the various tillage methods and identical water was applied to the tillage methods in this research; therefore, tillage methods had no drastic effect on the cotton water productivity.

Table 6- Variance analysis of cotton water productivity data

Variation resources	df	Mean square	F value
Replication	2	0.029	7.53**
Year	1	0.020	5.00*
Irrigation methods	2	0.143	36.68**
Tillage methods	2	0.007	1.76^{ns}
Year × Irrigation	2	0.016	4.15*
Year × Tillage	2	0.007	1.78^{ns}
Irrigation × Tillage	4	0.004	0.98^{ns}
Year × Irrigation × tillage	4	0.007	1.87^{ns}
Error	28	0.004	

^{ns}: Non-significant; *: significant at p<0.05; **: significant at p<0.01.

Means comparison of cotton water productivity showed that cotton had higher water productivity in the second year (0.26 kg m^{-3}) compared to the first year (0.22 kg m^{-3}) (Table 7). This was mostly because of the more moderate climate condition of the second year which resulted in higher crop yield this year. Results also indicated that drip tape irrigation had the maximum water productivity (0.324 kg m^{-3}) and surface irrigation had the minimum water productivity (0.146 kg m^{-3}). Means comparison of interaction between year and irrigation method revealed that there was no significant difference between drip tape and sprinkler irrigation from the water productivity point of view in the first year; while, this difference was significant in the second year. Drip tape irrigation had maximum water productivity in both years.

Water productivity is a function of two factors including water consumption (inverse relationship) and crop yield (direct relationship); therefore, in spite of having higher water application, the sprinkler irrigation had water productivity close to that of drip irrigation in 2010 because of having higher crop yield in this year. The results of this study also revealed that pressurized irrigation methods (drip tape and sprinkler irrigation) had higher water productivity in cotton production compared to surface irrigation; thus, surface irrigation should be replaced by pressurized irrigation systems in cotton growing. Cetin and Bilgel (2002) also reported that drip irrigation improved water use efficiency compared to furrow and sprinkler irrigation methods.

Results of means comparison of water productivity in different tillage methods indicated that there was no significant difference between tillage methods for water productivity; however, conservation tillage methods increased cotton water productivity for an average of 16% compared to the conventional tillage (Table 7).

Table 7- Means comparison of cotton water productivity in different treatments

Year		**Water Productivity (kg m^{-3})**
First year		0.222 b
Second year		0.260 a
Irrigation methods		-
Drip tape		0.324 a
Surface		0.146 c
Sprinkler		0.251 b
Tillage methods		-
Conventional tillage		0.218 a
Reduced tillage		0.253 a
No-tillage		0.250 a
Year × Irrigation		-
First year	Drip tape	0.281 a
First year	Surface	0.117 b
First year	Sprinkler	0.266 a
Second year	Drip tape	0.366 a
Second year	Surface	0.176 c
Second year	Sprinkler	0.236 b

a, b, c: Averages with different letters in each column are statistically different at $p<0.05$.

Soil bulk density

Variance analysis of soil bulk density data indicated that bulk density was affected by year and irrigation method at the soil depth of 0-100 mm; while, soil bulk density was affected by year and tillage method at the soil depth of 100-200 mm (Table 8). Results also showed that soil bulk density was not influenced by the interaction between irrigation and tillage methods.

Results revealed that soil had a higher bulk density in the first year compared to the second year that was probably because of more decomposed crop residue at the end of the second year (Table 9). Comparing soil bulk density in different irrigation methods showed that drip tape irrigation had the highest soil bulk density and surface irrigation had the lowest soil bulk density at the soil depth of 0-100 mm. Soil bulk density amount was inversely related to the soil organic matter, and soil organic matter was affected by the amount of decomposed crop residue. In drip tape irrigation, only a small fraction of crop residue was wetted by irrigation water; while, all crop residues were exposed to the irrigation water in the sprinkler and surface irrigation.

Therefore, soil organic matter was usually higher in the plots irrigated by tape irrigation compared to that of plots irrigated by sprinkler and surface irrigation. For this reason, plots irrigated with tape irrigation had higher soil bulk density compared to plots irrigated with sprinkler and surface irrigation methods.

Table 8- Variance analysis of soil bulk density data

Variation resources	0-100 mm			100-200 mm		
	df	**Mean square**	**F value**	**df**	**Mean square**	**F value**
Replication	2	0.005	3.45*	2	0.004	1.68 ns
Year	1	0.035	22.42**	1	0.041	18.38**
Irrigation methods	2	0.007	4.69*	2	0.004	1.77 ns
Tillage methods	2	0.003	2.16 ns	2	0.019	8.39**
Year × Irrigation	2	0.002	1.55 ns	2	0.005	2.14 ns
Year × Tillage	2	0.003	1.66 ns	2	0.002	0.95 ns
Irrigation × Tillage	4	0.001	0.80 ns	4	0.001	0.48 ns
Year × Irrigation × tillage	4	0.001	0.94 ns	4	0.005	2.18 ns
Error	28	0.002		28	0.002	

ns: Non-significant; *: significant at $p<0.05$; **: significant at $p<0.01$.

Conservation tillage methods (reduced and zero tillage) had a higher soil bulk density compared to the conventional tillage at the soil depth of 100-200 mm (Table 9). In the conservation tillage methods, soil disturbance was less than conventional tillage; therefore, soil bulk density was higher in conservation tillage methods compared to the conventional tillage. Results of some previous studies also show the higher soil bulk density in the conservation tillage methods compared to the conventional tillage (Afzalinia *et al.*, 2012; Liu *et al.*, 2005; Taser and Metinoglu, 2005). It should be noted that the difference between conservation and conventional tillage methods from the soil bulk density point of view is bigger at the beginning of the growing season compared to the end of growth season (Afzalinia and Zabihi, 2014).

Table 9- Means comparison of soil bulk density (g cm^{-3})

Treatments	0-100 mm	100-200 mm
Year	-	-
First year	1.37 a	1.44 a
Second year	1.32 b	1.38 b
Irrigation methods	-	-
Drip tape	1.36 a	1.43 a
Surface	1.33 b	1.40 a
Sprinkler	1.33 b	1.41 a
Tillage methods	-	-
Conventional tillage	1.36 a	1.37 b
Reduced tillage	1.34 a	1.44 a
No-tillage	1.33 a	1.42 a

a, b: Averages with different letters in each column are statistically different at $p<0.05$.

Table 10- Variance analysis of soil infiltration rate data

Variation resources	df	Mean square	F value
Replication	2	0.144	6.53**
Year	1	0.735	33.36*
Irrigation methods	2	0.584	26.50**
Tillage methods	2	0.319	14.47**
Year × Irrigation	2	0.132	5.98*
Year × Tillage	2	0.084	3.79*
Irrigation × Tillage	4	0.275	12.49**
Year × Irrigation × Tillage	4	0.122	5.55**
Error	28	0.022	

ns: Non-significant; *: significant at $p<0.05$; **: significant at $p<0.01$.

Soil infiltration rate

Variance analysis of soil infiltration rate data showed that year, irrigation methods, tillage methods, and interaction between irrigation and tillage methods had a significant influence on the soil infiltration rate (Table 10). Since soil disturbance and crop residue decomposition were different in various irrigation and tillage methods, a significant effect of irrigation and tillage methods on the soil infiltration rate was expected.

Results of means comparison of soil infiltration rate showed that plots had significantly higher infiltration rate in the second year compared to the first year which was probably because of the increase of soil organic matter due to crop residue retention on the soil in this research (Table 11). Comparing irrigation treatments for soil infiltration rate indicated that drip tape irrigation had the maximum soil infiltration rate which was not significantly different from that of sprinkler and surface irrigation had the minimum infiltration rate. Water reached the soil gradually in tape irrigation and clay leaching in this irrigation method was low; therefore, the soil had a more porous structure and higher infiltration rate in this irrigation system. In contrast, more clay leaching and adhesion of soil aggregates in surface irrigation slowed down the water movement in the soil in this irrigation system.

Table 11- Soil infiltration rate in different irrigation and tillage methods

Year			**Soil infiltration rate (mm min^{-1})**
First year			0.79 b
Second year			1.03 a
Irrigation methods			-
Drip tape			1.08 a
Surface			0.72 b
Sprinkler			0.92 ab
Tillage methods			-
Conventional tillage			1.06 a
Reduced tillage			0.80 b
No-tillage			0.88 b
Year × Irrigation× Tillage			-
First year	Drip tape	Conventional tillage	1.07 c
		Reduced tillage	0.81 d
		No-tillage	0.86 d
First year	Surface	Conventional tillage	0.53 e
		Reduced tillage	0.59 e
		No-tillage	0.58 e
First year	Sprinkler	Conventional tillage	1.02 c
		Reduced tillage	0.63 e
		No-tillage	1.06 c
Second year	Drip tape	Conventional tillage	1.62 a
		Reduced tillage	1.36 b
		No-tillage	0.78 d
Second year	Surface	Conventional tillage	0.81 d
		Reduced tillage	0.72 d
		No-tillage	1.11 c
Second year	Sprinkler	Conventional tillage	1.28 b
		Reduced tillage	0.67 de
		No-tillage	0.88 d

a, b, c: Averages with different letters in each column are statistically different at $p<0.05$.

Results of means comparison of soil infiltration rate in different tillage methods revealed that conventional tillage had the highest soil infiltration rate compared to the conservation tillage methods (Table 11). The minimum soil infiltration rate was related to the reduced tillage; however, there was no significant difference between reduced and no-tillage for soil infiltration rate. The higher soil infiltration rate in the conventional tillage was probably because of more soil disturbance in this tillage method. Means comparison of soil infiltration rates affected by the interaction between irrigation and tillage methods indicated that conventional tillage method irrigated by tape irrigation had the maximum soil infiltration rate and the reduced tillage method irrigated by sprinkler and surface irrigation had the minimum soil infiltration rate (Table 11).

Conclusions

The following conclusions can be drawn from the results of this research:

1. The cotton yield was not affected by tillage methods in a short research period; while, irrigation methods had a significant effect on cotton yield. Pressurized irrigation systems produced more cotton yield on average compared to surface irrigation; therefore, conservation tillage methods irrigating with drip tape and sprinkler irrigation system was recommended for cotton growing in semi-arid climate conditions of Iran.
2. The maximum water was applied in surface irrigation and the minimum water application was related to the drip tape irrigation. Drip tape and sprinkler irrigation methods saved water for 51 and 28% and increased water productivity for 120 and 71% in growing cotton compared to surface irrigation, respectively.
3. Conservation tillage methods increased the soil bulk density compared to the conventional tillage in growing cotton. Tape irrigation had also the higher soil bulk density among the irrigation systems tested.
4. Drip tape irrigation treatment had the maximum soil infiltration rate and the minimum infiltration rate belonged to surface irrigation. Among the tillage methods tested, the conventional tillage treatment had a higher infiltration rate.

Acknowledgments

The authors would like to acknowledge the financial support extended by the Agriculture Organization of Fars province and Agricultural Engineering Research Institute. Technical supports from colleagues in the Department of Agricultural Engineering Research during the experimental works are also appreciated.

References

1. Afzalinia, S., E. Dehghanian, and M. H. Talati. 2009. Effect of conservation tillage on soil physical properties, fuel consumption, and wheat yield. Fourth Conference on Energy Efficiency and Agricultural Engineering, Rousse, Bulgaria.
2. Afzalinia, S., A. Karami, and S. M. Alavimanesh. 2012. Comparing Conservation and Conventional Tillage Methods in Corn-Wheat Rotation. International Conference of Agricultural Engineering, Valencia, Spain.
3. Afzalinia, S., and J. Zabihi. 2014. Soil compaction variation during corn growing season under conservation tillage. Soil and Tillage Research 137: 1-6.
4. Ahmadi, K., H. R. Ebadzadeh, H. Abdshah, A. Kazemian, and M. Rafiee. 2018. Agricultural statistics of 2016-2017 growing season. Ministry of Jehad-e-Agriculture, Tehran, pp 116.
5. Ali, M. H., and M. S. U. Talukder. 2008. Increasing water productivity in crop production-A synthesis. Agricultural Water Management 95: 1201-1213.
6. Black, G. R., and K. H. Harte. 1986. Bulk density, core method in methods of soil analysis, part 1. Agronomy Monograph 9: 363-366.
7. Cetin, O., and L. Bilgel. 2002. Effects of different irrigation methods on shedding and yield of cotton. Agricultural Water Management 54: 1-15.
8. Dehghanian, S. E., and S. Afzalinia. 2012. Effect of conservation tillage and irrigation methods on the crop yield and water use efficiency in wheat-corn rotation. International Conference of Agricultural Engineering, Valencia, Spain.

9. De Vita, P., E. Di Paolo, G. Fecondo, N. Di Fonzo, and M. Pisante. 2007. No-tillage and conventional tillage effects on durum wheat yield, grain quality and soil moisture content in southern Italy. Soil & Tillage Research 92: 69-78.
10. Erenstein, O., and V. Laxmi. 2008. Zero tillage impacts in India’s rice–wheat systems: A review. Soil & Tillage Research 100: 1-14.
11. Eskandari, I., and V. Feiziasl. 2017. Influence of conservation tillage on some soil physical properties and crop yield in vetch-wheat rotation in dryland cold region. Journal of Agricultural Machinery 7 (2): 451-467. (In Farsi).
12. Fabrizzi, K. P., F. O. Garc´, J. L. Costa, and L. I. Picone. 2005. Soil water dynamics, physical properties and corn and wheat responses to minimum and no-tillage systems in the southern Pampas of Argentina. Soil & Tillage Research 81: 57-69.
13. Freebairn, D. M., L. D. Ward, A. L. Clarke, and G. D. Smith. 1986. Research and development of reduced tillage systems for vertisols in Queensland, Australia. Soil & Tillage Research 8: 211-229.
14. Haq, N. 1990. Evaluation of modern irrigation techniques for sandy loam soil having low slopes. Department of Irrigation and Drainage, University of Agriculture, Faisalabad.
15. Jalota, S. K., G. S. Buttar, A. Sood, G. B. S. Chahal, S. S. Ray, and S. Panigrahy. 2008. Effects of sowing date, tillage and residue management on productivity of cotton (*Gossypium hirsutum* L.)-wheat (*Triticum aestivum* L.) system in northwest India. Soil & Tillage Research 99: 76-83.
16. Jat, M. L., A. Srivastava, S. K. Sharma, R. K. Gupta, P. H. Zaidi, H. K. Rai, and G. Srinivasan. 2005. Evaluation of maize-wheat cropping system under double no-till practice in Indo-Gangetic Plains of India. 9th Asian Regional Maize Workshop, Beijing, China.
17. Karamanos, A. J., D. Bilalis, and N. Sidiras. 2004. Effects of reduced tillage and fertilization practices on soil characteristics, plant water status, growth and yield of upland cotton. Journal of Agronomy and Crop Science 190: 262-276.
18. Keeling, W., E. Searra, and J. R. Abernathy. 1989. Evaluation of conservation cropping systems for cotton on the Texas southern high Plains. Journal of Production Agriculture 2 (3): 269-273.
19. Kostiakov, A. N. 1932. On the dynamics of the coefficient of water percolation in soils and on the necessity for studying it from a dynamic point of view for purposes of amelioration. Trans. 6 Comm. Intern. Soil Sci. Russian, Part A, 17-21.
20. Latif, M. 1990. Sprinkler irrigation to harness potential of water scarcity area in Pakistan. Technical Report No. 41. CEWRE. Pub. No. 37.
21. Liu, S., H. Zhang, Q. Dai, H. Huo, Z. K. Xu, and H. Ruan. 2005. Effects of no-tillage plus inter-planting and remaining straw on the field on cropland eco-environment and wheat growth. Ying Yong Sheng Tai Xue Bao 16: 393-396.
22. McGarry, D., B. J. Bridge, and B. J. Radford. 2000. Contrasting soil physical properties after zero and traditional tillage of an alluvial soil in semi-arid subtropics. Soil &Tillage Research 53: 105-115.
23. Naudin, K., E. Goze, O. Balarabe, K. E. Giller, and E. Scopel. 2010. Impact of no tillage and mulching practices on cotton production in North Cameroon: A multi-locational on-farm assessment. Soil & Tillage Research 108: 68-76.
24. Parihar, C. M., S. L. Jat, A. K. Singh, A. Ghosh, N. S. Rathore, B. Kumar, S. Pradhan, K. Majumdar, T. Satyanarayana, M. L. Jat, Y. S. Saharawat, B. R. Kuri, and D. Saveipune. 2017. Effects of precision conservation agriculture in a maize-wheat-mungbean rotation on crop yield, water-use and radiation conversion under a semiarid agro-ecosystem. Agricultural Water Management 192: 306-319.

25. Schomberg, H. H., R. G. McDaniel, E. Mallard, D. M. Endale, D. S. Fisher, and M. L. Cabrera. 2006. Conservation tillage and cover crop influences on cotton production on a southeastern U.S. Coastal Plain soil. Agronomy Journal 98: 1247-1256.
26. Taser, O., and F. Metinoglu. 2005. Physical and mechanical properties of a clay soil as affected by tillage systems for wheat growth. Acta Agriculture Scandinavica Section B-soil and Plant 55: 186-191.

Journal of Agricultural Machinery
Vol. 10, No. 1, Spring- Summer 2020, p. 103-114

نشریه ماشین‌های کشاورزی
جلد ۱۰، شماره ۱، نیمسال اول ۱۳۹۹، ص ۱۱۴-۱۰۳

عملکرد پنبه و بهره‌وری مصرف آب تحت تأثیر روش‌های خاک‌ورزی حفاظتی و آبیاری در تناوب پنبه-گندم

صادق افضلی نیا[1]*، علیرضا ضیایی[2]

تاریخ دریافت: ۱۳۹۷/۰۸/۰۴
تاریخ پذیرش: ۱۳۹۷/۱۲/۱۹

چکیده

در این تحقیق، اثر روش‌های خاک‌ورزی حفاظتی و آبیاری بر خصوصیات خاک، عملکرد پنبه و کارایی مصرف آب در تناوب گندم-پنبه در قالب طرح آزمایشی اسپلیت پلات بررسی شد. فاکتور اصلی روش آبیاری شامل آبیاری سطحی، قطره‌ای نواری و بارانی بود. روش‌های خاک‌ورزی شامل بی‌خاک‌ورزی، کم‌خاک‌ورزی و خاک‌ورزی مرسوم نیز به‌عنوان فاکتور فرعی در نظر گرفته شدند. نتایج نشان داد که روش خاک‌ورزی اثر معنی‌داری بر عملکرد پنبه نداشت، در حالی‌که عملکرد پنبه تحت تأثیر معنی‌دار روش آبیاری قرار گرفت ($p<0.05$). روش‌های آبیاری قطره‌ای نواری و بارانی در مقایسه با آبیاری سطحی مصرف آب را به‌ترتیب ۵۱ و ۲۸ درصد کاهش دادند. آبیاری قطره‌ای نواری بیشترین مقدار کارایی مصرف آب (۰/۳۲۴ کیلوگرم بر متر مکعب) را داشت و کمترین مقدار کارایی مصرف آب (۰/۱۴۶ کیلوگرم بر متر مکعب) مربوط به آبیاری سطحی بود. همچنین، نتایج نشان داد که روش‌های خاک‌ورزی و آبیاری اثر معنی‌داری بر جرم مخصوص ظاهری و نفوذپذیری خاک داشتند، به‌طوری‌که آبیاری قطره‌ای نواری و خاک‌ورزی مرسوم بیشترین نفوذپذیری خاک را داشتند و بیشترین جرم مخصوص ظاهری خاک مربوط به آبیاری قطره‌ای نواری و کم‌خاک‌ورزی بود.

واژه‌های کلیدی: پنبه، جرم مخصوص ظاهری خاک، روش‌های خاک‌ورزی، کارایی مصرف آب، نفوذپذیری خاک، مصرف آب

۱- بخش تحقیقات فنی و مهندسی کشاورزی، مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی فارس، سازمان تحقیقات، آموزش و ترویج کشاورزی، شیراز، ایران
۲- بخش تحقیقات فنی و مهندسی کشاورزی، مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی فارس، ایستگاه تحقیقات داراب، سازمان تحقیقات، آموزش و ترویج کشاورزی، داراب، ایران
(*- نویسنده مسئول: Email: sja925@mail.usask.ca)

DOI: 10.22067/jam.v10i1.76229