

DETERMINATION OF DIFFERENT SOIL TILLAGE METHODS EFFECTS ON IRRIGATION WATER SAVING TO SILAGE MAIZE GROWN UNDER ERZURUM PLATEAU

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ERZURUM PLATOSUNDA YETİŞTİRİLEN SİLAJLIK MISIRDA FARKLI TOPRAK İŞLEME METODLARININ SULAMA SUYUNDAN TASARRUF EDİLMESİ ÜZERİNDEKİ ETKİLERİNİN BELİRLENMESİ

Abstract:

In order to determine the effects of deficit irrigations and different tillage application methods on the yield and irrigation water use efficiency of silage maize, field experiments were conducted in Erzurum Pasinler plateau in 2015, 2016 and 2017 years. In the study, three different soil tillage techniques: Conventional Tillage (C), Reduced Tillage (R) and No Tillage (N) and four irrigation applications: I 1: 1,00 Full Irrigation, I 2: 0,75 Deficit Irrigation, I 3: 0,50 Deficit Irrigation and I 4: 0,25 Deficit Irrigation were investigated to examine the effect of yields. In order to measure the amount of irrigation water at 90 cm soil depth, access tubes were placed to each sub plots. Neutron probe was used for monitoring of irrigation efficiencies at 0-30 cm, 30-60 cm and 60-90 cm soil depths, before and after irrigation applications. For I 2, I 3 and I 4 treatments, irrigations were immediately done by using drip irrigation systems once the available water content at the effective root zone reduced to 50 % of full irrigation. Experimental results obtained from 2015, 2016 and 2017 years stated that no-tillage subject and 0,75 deficit irrigation subject can be recommended to local producers in order to obtain economic efficiency in silage maize. After three years field study, neutron probe calibration equation and volumetric soil water content formula was found as $r^2 = 0,7628$ and $Y = 14,571 X + 0,3285$, respectively.

Özet:

Kısıntılı sulama uygulamaları ve farklı toprak işleme yöntemlerinin silajlık mısır'da verim ve sulama suyu kullanım etkinliğini belirlemek amacıyla, 2015, 2016 ve 2017 yıllarında Erzurum Pasinler Yaylası'nda tarla denemeleri yapılmıştır. Çalışmada, üç farklı toprak işleme tekniği Geleneksel Toprak İşleme (C), Azaltılmış Toprak İşleme (R) ve Sıfır Sürüm (N) ile dört sulama uygulamasının I 1: Tam Sulama, I 2: 0,75 Kısıntılı Sulama, I 3: 0,50 Kısıntılı Sulama ve I 4: 0,25 Kısıntılı Sulama'nın verimler üzerindeki etkileri incelenmiştir. 90 cm toprak derinliğinde sulama suyu miktarlarını ölçmek için her bir alt parselde access tüpleri yerleştirilmiştir. Sulama öncesi ve sulama sonrası 0-30, 30-60 ve 60-90 cm toprak derinliğinde sulama etkilerinin izlenmesi için nötron prob kullanılmıştır. Sulamalar I 2, I 3 ve I 4 uygulamaları için, tam sulama uygulamasında etkili kök derinliği bölgesindeki mevcut su içeriği % 50'nin altına düşer düşmez, damla sulama sistemleri kullanılarak yapılmıştır. 2015, 2016 ve 2017 yıllarından elde edilen deneme sonuçlarına göre, silajlık mısırdaki ekonomik verim elde edilmesi için sıfır sürüm konusu ve % 75'lik kısıntılı sulama konusu yöre üreticilerine tavsiye edilmektedir. Üç yıl tarla çalışmaları sonrasında, nötron prob kalibrasyon eşitliği ve hacimsel toprak su miktarı formülü sırasıyla $r^2 = 0,7628$ ve $Y = 14,571 X + 0,3285$ olarak bulunmuştur.

Key words: Silage maize, tillage practices, water deficit, neutron probe

Anahtar Kelimeler: Silajlık mısır, sürüm teknikleri, kısıntılı su, nötron prob

1. Introduction

The important inputs for plant production are soil tillage, irrigation and fertilization for high quality and quantity yields. Excessive irrigation water application may lead to fertilizer leaching beyond the root zone due to deep percolation and cause low yield, environmental pollution and money loses. In order to determine of economic efficiency, precise irrigation water programmes are required for silage maize plant. Silage maize plays an important role for nutritional requirements of animals, especially dairy cattle. Turkey's silage production is supplied by maize and the proportion of it is by about 95%. (Ucak, Ayasan & Turan, 2016). The silage maize cultivation area is rising up in Turkey, especially in the Eastern Anatolia Region. Erzurum is one of the most important region in North East Anatolia where around 91 944 tons of silage maize was produced in 2016 (Turkish Statistical Institute, TSI 2017). Soil tillage, maintenance, irrigation and fertilization are mainly factors for obtaining high quality and quantity products. The leaching of the fertilizer due to excessive irrigation applications through deep percolation causes low yield and environmental pollution. Therefore, it is necessary to determine an appropriate tillage, irrigation and fertilization programs in order to obtain economic benefits for maize production. Soil tillage systems are changing as a result of the necessity of economic production on agriculture in recent years. Baran, Karaağaç & Gökdoğan (2016), Haddadi (2016) stated that the direct sowing is widespreadly using in the world and alternative to conventional soil tillage management. Khaledian et al. 2010 studied with direct sowing on corn plant. Direct

sowing contributes to soil conservation and soil fertility, protecting soil moisture, and providing various environmental benefits for agricultural production. Performed experiment results showed that high soil moisture content was observed under the direct sowing practices (Gozubuyuk et al. 2014, 2015; Lasisi, Adesola & Ogunsola, 2014; Gozubuyuk et al., 2017). Direct sowing requires less energy and labor (Gozubuyuk et al. ,2012). Direct tillage applications contribute to economy by providing energy savings, preservation of fossil resources and release to less CO₂ emissions (Stajanko et al., 2009; Lu & Lu, 2017). Ors, Sahin & Kiziloglu (2015) stated that silage maize is sensitive to water in the soil and found linear relation between water and yield. The influence of different irrigation levels on maize crop yield performance were investigated using by only conventional tillage technique in many studies (Simsek et al. 2011; Bouazzama et al. 2012; Ors Sahin & Kiziloglu, 2015; Ucak, Ayasan & Turan, 2016). Khurana & Kahlon (2016) studied on the effects of the soil tillage practices and irrigation levels. They stated that the no-tillage application was increased to water storage in the soil and improved the maize stover yield. Kiziloglu et al. (2009) studied on the deficit water application strategies on the silage maize yields in two year field studies. Obtained results indicated that silage maize yields were significantly reduced. Gheysari et al. (2009) stated that total biomass of silage maize were affected by irrigation water and also by N fertilizer application under drought conditions. The scarcity of water in the soil is the main limiting factor for obtaining high maize production under semi-arid regions. Soil water conservation can be improved by different soil tillage methods. For that reason, field experiments were conducted to determine the most suitable soil tillage methods for increasing silage maize production under Erzurum local farmer conditions during three years.

2. Material and methods

The field experiments were done at Pasinler experimental station in East Anatolian Agricultural Research Institute in Erzurum in 2015, 2016 and 2017 years. Research center was located in Erzurum plateau. It has semi-arid climate as the yearly average precipitation is 423.5 mm and the mean temperature is 6.1 °C (Doğu Anadolu Tarımsal Araştırma Enstitüsü, DATAE 2016). The average daily air temperatures and precipitation data during growing seasons were recorded (Table 1). Precipitation values were recorded by a pluviometer in the area nearest to the experiment field. According to the USDA soil classification, soil type in the region is Inceptisol (Özgül 2003). The soil texture class at 0–120 cm was clay loam (Table 2). Irrigation water analysis was given in Table 3. The field experiments were conducted as a split-plot randomized complete block design with two factors. Three different tillage applications as the main treatments and four different irrigation levels as the sub-treatments were tested with three replications. Tillage practices were applied as (C) conventional tillage, (R) reduced tillage and (N) no-tillage. Irrigation treatments were applied as full irrigation level (I1), and three deficit irrigation levels (I2), (I3) and (I4) which were received 25, 50 and 75 % less water from full irrigation level I1, respectively. Plot sizes were adjusted to 4.6 m × 15 m considering standard row spacing of the no-till seeder used. DKC 5783 variety of silage maize seeds were sown on the beginning of June with sowing rates of 21.70 kg/ha for C and R treatments, and 22.78 kg/ha for

N treatment. Row spacing and the seed spacing were arranged to 70 cm and 15 cm, respectively for C and R applications, and 76.8 cm and 13 cm, respectively for N application. All parcels were fertilized before planting with 260 kg P_2O_5 /ha triple super phosphate (42-45 % P_2O_5) and 120 kgN/ha ammonium nitrate (33 % N) fertilizers according to soil analysis results. Ammonium nitrate fertilizer at a dose of 120 kg N/ha was applied to all parcels on growing season by drip irrigation system. Herbicides for weed control were applied using a pulverizator. Surface drip irrigation system was used for irrigation. The system had a pump, manifold, sand filter, 4 water meters, 4 valves, 4 pipelines and drip lines. The drip lines were placed in the middle of two plants row with a spacing of 140 cm in the C and R treatments, and 154 cm in the N treatment. Results of irrigation water analysis showed that good quality water with values of pH: 7,45, electrical conductivity, EC: 225,58 μ mhos/cm and sodium adsorption rate, SAR: 0,64 was used. Deficit irrigation applications were started when the plants had 6-8 leaves. Applications were done when the soil moisture content in 90 cm soil depth depleted to 50 % of available soil moisture for full irrigation (I1) treatment. Soil moisture contents were measured by neutron probe for I1 parcels before each irrigation (Figure 1). The current moisture contents in 90 cm soil depth were calculated, and then supplemental irrigation water applied to all I1 parcels at an amount of field capacity. When I1 parcels irrigated, deficit irrigations of 25 %, 50 % and 75 % were applied to I2, I3 and I4 parcels on the same time, respectively. Irrigation was ended at the dough stage of grains. Totally, 6 irrigations were done during growing period. Plants were harvested by a silage machine for fresh silage maize yields on the mid of September. The amount of fresh silage maize yields were weighted for all treatments. Field calibration of neutron probe was performed by taking undisturbed core soil samples at depths of 0-30, 30-60 and 60-90 cm from dry and wet calibration parcels, before experiment installation. The soil samples were fastly placed in tin cans and after weighed, then oven dried at 100°C for 48 hours and weighed again. Volumetric soil moisture content was calculated according to Shock et al. (2016)'s gravimetric method. The neutron probe was read in access tubes at the same time as the soil samples were taken. The neutron probe was read as counts during 32 seconds. Four Standard counts were also made at four times. The volumetric soil water content determined from the soil samples was regressed against the ratio of the neutron probe counts, R, at different soil depths to the standard count, R_s . The regression equation transforming the neutron probe readings to volumetric water content was; $Y = 14,571 X + 0,3285$. X is the ratio of the neutron probe soil count to the standard neutron probe count and Y is the percent volumetric soil water content. The coefficient of determination for the neutron probe calibration equation was $r^2 = 0,7628$ (Figure 2).



Figure 1. Neutron probe readings for I1 parcels before each irrigation

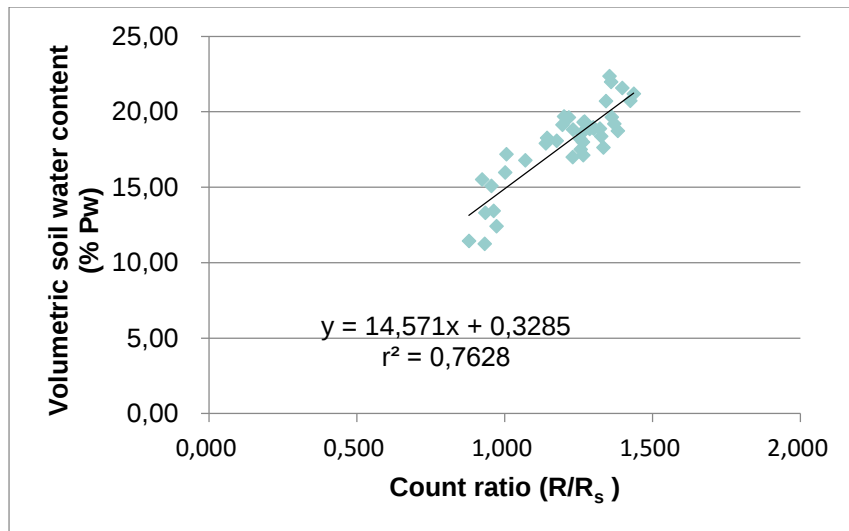


Figure 2. Calibration of the neutron probe to volumetric soil water content

3. Tables

Table 1. Average of long term climatic data for Erzurum (DATAE, 2016).

Climatic data	Months											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Total rain (mm)	19,5	22,9	31,5	56,2	68,1	45,3	26,3	17,0	21,0	46,5	31,9	21,3
Average temperature	-9,9	-8,2	-2,2	5,5	10,4	14,9	19,3	19,3	14,4	7,8	0,1	-6,6

Ave. max. temperature	-4,3	-2,5	3,1	11,5	16,9	21,9	26,9	27,4	23,1	15,4	6,3	-1,0
Ave. min temperature	-15,2	-13,6	-7,1	-0,1	3,7	6,7	10,6	10,4	5,5	1,0	-5,1	-11,5
Extreme max. Temp.	7,7	9,6	21,4	26,5	27,2	31,0	35,6	36,5	33,3	27,0	17,8	14,0
Extreme min. Temp. (°C)	-36,0	-37,0	-33,2	-22,4	-7,1	-5,6	-1,8	-1,1	-6,8	-14,1	-34,3	-37,2

Table 2. Some soil characteristics of the experimental site

Soil depth (cm)	Field capacity		Wilting point		Volumetric weight (gr/cm ³)	Texture Analysis (%)			Texture class
	Pw	mm	Pw	mm		Sand	Silt	Clay	
0-30	27.91	93.78	14.76	49.59	1.12	30.44	42.06	27.50	CL
30-60	31.96	106.43	15.01	49.98	1.11	30.32	41.28	28.40	CL
60-90	33.36	109.09	17.34	56.70	1.09	26.94	37.28	35.78	CL
90-120	32.43	107.99	16.69	55.58	1.11	22.30	49.10	28.60	CL

Table 3. Analysis of irrigation water

EC µmhos/cm	pH	Na ⁺ me/l	K ⁺ me/l	Ca ⁺⁺ me/l	Mg ⁺⁺ me/l	CO ₃ ⁻² me/l	HCO ₃ ⁻ me/l	Cl ⁻ me/l	SO ₄ ⁻² me/l	SAR
225,58	7,45	0,64	0,21	1,2	0,8	-	1,96	0,8	0,09	0,64

Table 4. Average of silage maize yield, water use efficiency (WUE) and irrigation water use efficiency (IWUE) values, 2015

Sub parcel	Main parcel	Yield (kg/da)	Water consumption (mm) (ETa)	Applied irrigation (mm) (I)	WUE (kg/ha/mm)	IWUE (kg/ha/m ³)
I 1	C	7780.3	290.00	169.56	26.8	45.9
	R	7690.6	280.40	169.56	27.4	45.4
	N	8500.0	273.20	169.56	31.1	50.1
I 2	C	6849.6	269.70	136.95	25.4	50.0
	R	6891.2	265.50	136.95	26.0	50.3
	N	7565.5	257.10	136.95	29.4	55.2
I 3	C	5912.4	237.10	104.35	24.9	56.7
	R	5969.7	246.30	104.35	24.2	57.2

	N	6676.1	237.50	104.35	28.1	64.0
I 4	C	5218.1	234.60	71.74	22.2	72.7
	R	5265.1	223.90	71.74	23.5	73.4
	N	5803.9	214.50	71.74	27.1	80.9

Table 5. Results of variance analysis of silage maize yield (kg/da), 2015

		Silage yields (kg/da)				
		The average of sub-parcels				The average of main-parcels
		I 1	I 2	I 3	I 4	
		7990 a	7102 b	6186 c	5429 d	
Main parcels	C	7780	6850	5912	5218	6440 b
	R	7691	6891	5970	5265	6454 b
	N	8500	7566	6676	5804	7136 a

Table 6. Results of variance analysis of total moisture content (% Pw) at 0-90 cm soil depth, 2015

		Moisture content (% Pw)				
		The average of sub-parcels				The average of main-parcels
		I 1	I 2	I 3	I 4	
		15.41 a	14.14 b	13.00 c	12.05 d	
Main parcels	C	14.69	13.68	12.44	11.20	13.00 c
	R	15.48	14.03	12.93	12.09	13.63 b
	N	16.07	14.72	13.65	12.87	14.33 a

Table 7. Average of silage maize yield, water use efficiency (WUE) and irrigation water use efficiency (IWUE), 2016

Sub parcel	Main parcel	Yield (kg/da)	Water consumption (mm) (ETa)	Applied irrigation (mm) (I)	WUE (kg/ha/mm)	IWUE (kg/ha/m ³)
I 1	C	6776	449	241.6	15.1	28.0

	R	6483	451	241.6	14.4	26.8
	N	7522	445	241.6	16.9	31.1
I 2	C	5697	414	181.2	13.7	31.4
	R	5594	416	181.2	13.4	30.9
	N	6455	414	181.2	15.6	35.6
I 3	C	4831	365	120.8	13.2	40.0
	R	4760	370	120.8	12.8	39.4
	N	5368	364	120.8	14.7	44.4
I 4	C	3934	308	60.4	12.8	65.1
	R	3983	313	60.4	12.7	66.0
	N	4227	302	60.4	14.0	70.0

Table 8. Results of variance analysis of silage maize yield (kg/da), 2016

		Silage yields (kg/da)				
		The average of sub-parcels				The average of main-parcels
		I 1	I 2	I 3	I 4	
		6927 a	5915 b	4987 c	4049 d	
Main parcels	C	6776	5697	4831	3934	5310 b
	R	6483	5594	4760	3983	5205 c
	N	7522	6455	5368	4229	5893 a

Table 9. Results of variance analysis of total moisture content (% Pw) at 0-90 cm soil depth, 2016

		Moisture content (% Pw)				
		The average of sub-parcels				The average of main-parcels
		I 1	I 2	I 3	I 4	
		16,81 a	14,53 b	13,64 c	13,24 c	
Main parcels	C	16,77	14,56	13,66	13,32	14,58
	R	16,57	14,42	13,18	12,92	14,27
	N	17,10	14,60	14,08	13,47	14,81

Table 10. Average of silage maize yield, water use efficiency (WUE) and irrigation water use efficiency (IWUE), 2017

Sub parcel	Main parcel	Yield (kg/da)	Water consumption (mm) (ETa)	Applied irrigation (mm) (I)	WUE (kg/ha/mm)	IWUE (kg/ha/m ³)
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I 1	C	7512	460.4	314.8	16.3	23.9
	R	7739	464.2	314.8	16.7	24.6
	N	8224	464.5	314.8	17.7	26.1
I 2	C	6398	407.0	236.1	15.7	27.1
	R	6515	415.6	236.1	15.7	27.6
	N	6939	418.2	236.1	16.6	29.4
I 3	C	5126	351.1	157.4	14.6	32.6
	R	5282	362.6	157.4	14.6	33.6
	N	5922	365.6	157.4	16.2	37.6
I 4	C	3458	279.6	78.7	12.4	43.9
	R	4171	289.5	78.7	14.4	53.0
	N	4533	294.5	78.7	15.4	57.6

Table 11. Results of variance analysis of silage maize yield (kg/da), 2017

		Silage yields (kg/da)				
		The average of sub-parcels				The average of main-parcels
		I 1	I 2	I 3	I 4	
		7825 a	6617 b	5443 c	4054 d	
Main parcels	C	7512	6398	5126	3458	5623
	R	7739	6515	5282	4171	5927
	N	8224	6939	5922	4533	6404

Table 12. Results of variance analysis of total moisture content (% Pw) at 0-90 cm soil depth,2017

		Moisture content (% Pw)				
		The average of sub-parcels				The average of main-parcels
		I 1	I 2	I 3	I 4	
		17.02 a	14.58 b	12.51 c	11.90 d	
Main parcels	C	16.53	14.43	12.50	11.90	13.84
	R	16.97	14.47	12.40	11.84	13.92
	N	17.55	14.86	12.64	11.96	14.25

4. Results and Discussion

Results of 2015 year: The averages of total silage maize yield were found in conventional tillage, reduced tillage and no tillage treatments as 6440, 6454 and 7136 kg/da, respectively (Table 5). Total yield values were affected by tillage treatments. For all irrigation applications, highest yield value was obtained in the no tillage treatment as compared to other tillage treatments, and this value was found statistically significant ($P<0.01$). Also, total yield values had affected by full irrigation, 75 % deficit irrigation, 50 % deficit irrigation and 25 % deficit irrigation treatments, and found as 7990, 7102, 6186 and 5429 kg/da, respectively (Table 5). High yield (7990 kg/da) was obtained from full irrigation level, and it was statistically significant ($P<0.01$). Besides, 7120 kg/da yield obtained from I2 irrigation level was also reasonable for silage maize (Figure 3).

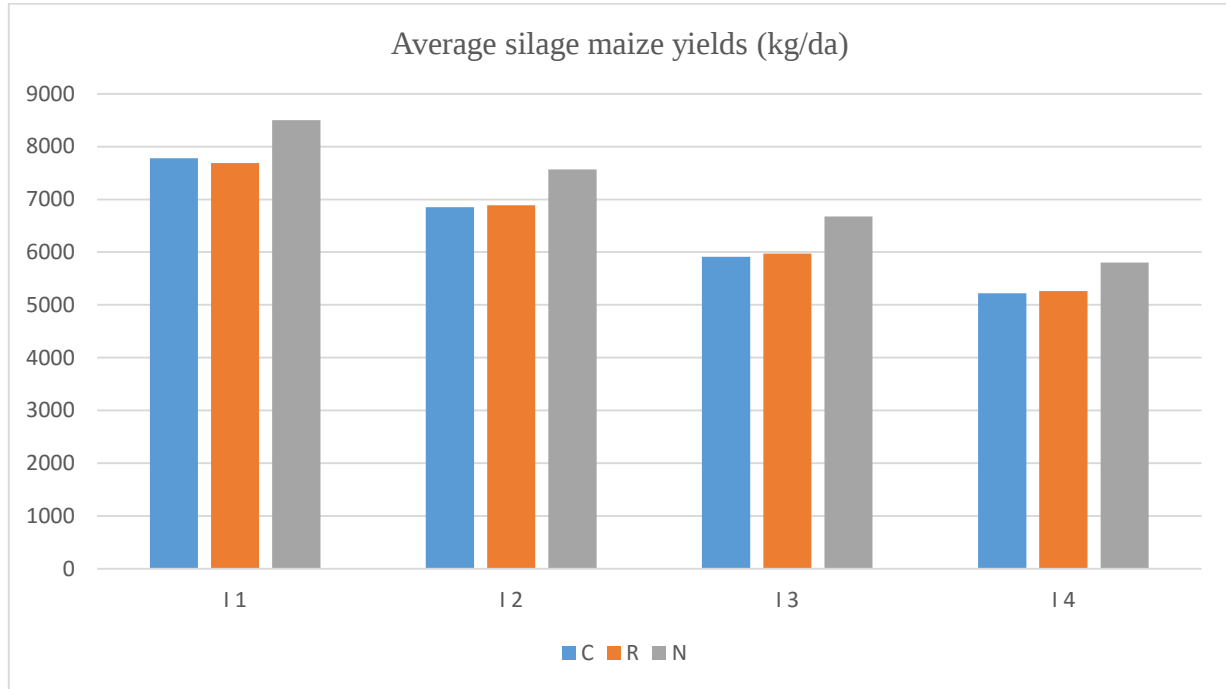


Figure 3. Silage maize yields (kg/da)

The averages of total moisture content (% Pw) at 0-90 cm soil depth were found in conventional tillage, reduced tillage and no tillage treatments as 13,00, 13,63 and 14,33 %, respectively (Table 6). Total moisture content at 0-90 cm soil profile had affected by tillage treatments. Highest moisture content in the soil profile was obtained by no tillage as compared to other tillage treatments for all irrigation applications, and it was found statistically significant ($P<0.01$). Total moisture content had affected by full irrigation, 75 % deficit irrigation, 50 % deficit irrigation and 25 % deficit irrigation treatments, and found as 15,41, 14,14, 13,00 and

12,05 %, respectively (Table 6). High moisture content (15,41 %) was obtained in full irrigation level, and it was found at $P<0.01$ level (Figure 4).

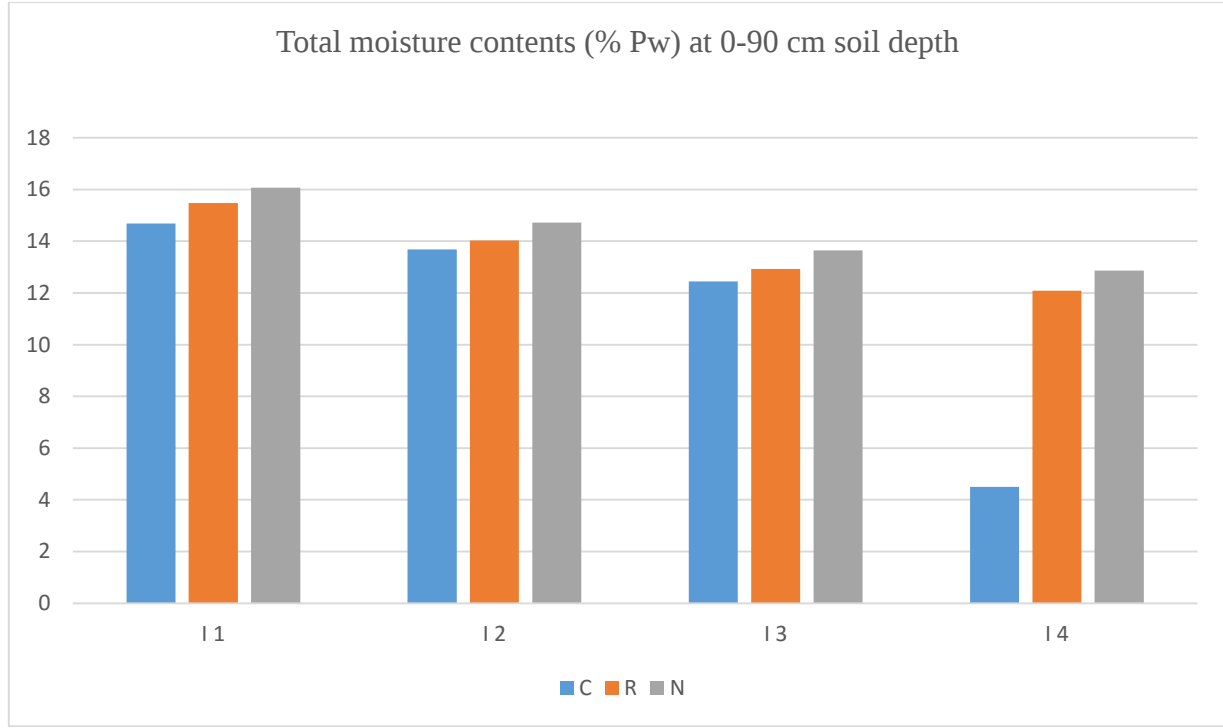


Figure 4. Total moisture contents (% Pw)

Results of 2016 year: The averages of total silage maize yield were found in conventional tillage, reduced tillage and no tillage treatments as 5310, 5205 and 5893 kg/da, respectively (Table 8). Total yield values were affected by tillage treatments. Highest yield value was obtained in no tillage as compared to other tillage treatments for all irrigation applications, and these value was found statistically significant ($P<0.01$). Also, total yield values had affected by full irrigation, 75 % deficit irrigation, 50 % deficit irrigation and 25 % deficit irrigation treatments, and found as 6927, 5915, 4987 and 4049 kg/da, respectively (Table 8). High yield (6927 kg/da) was obtained in full irrigation level, and it was statistically significant ($P<0.01$). Total yield of 5915 kg/da obtained in I2 irrigation level was also reasonable yield for 2016 year results (Figure 5).

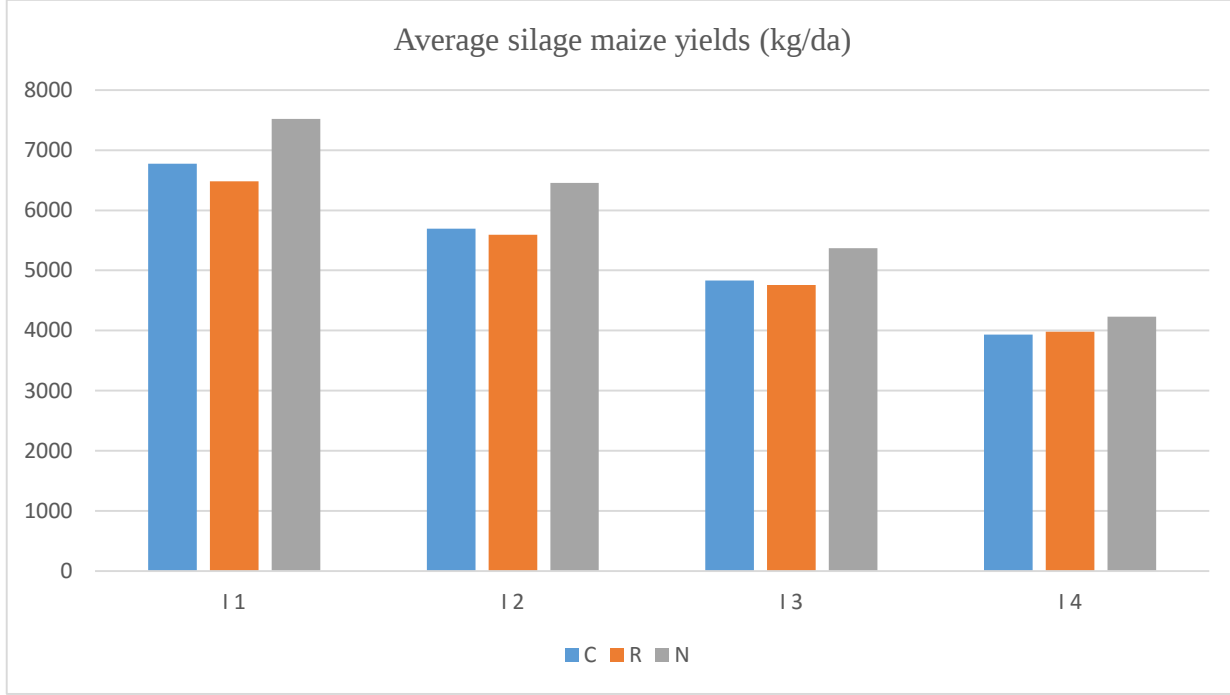


Figure 5. Silage maize yields (kg/da)

The averages of total moisture content (% Pw) at 0-90 cm soil depth were found in conventional tillage, reduced tillage and no tillage treatments as 14,58, 14,27 and 14,81 %, respectively (Table 9). Total moisture content at 0-90 cm soil profile had affected by tillage treatments. Highest moisture content in the soil profile was obtained by no tillage as compared to other tillage treatments for all irrigation applications, and it was found statistically significant ($P < 0.01$). Total moisture content values had affected by full irrigation, 75 % deficit irrigation, 50 % deficit irrigation and 25 % deficit irrigation treatments, and found as 16,81, 14,53, 13,64 and 13,24 %, respectively (Table 9). High moisture content (16,81 %) was obtained in full irrigation level, and it was found at $P < 0.01$ level (Figure 6).

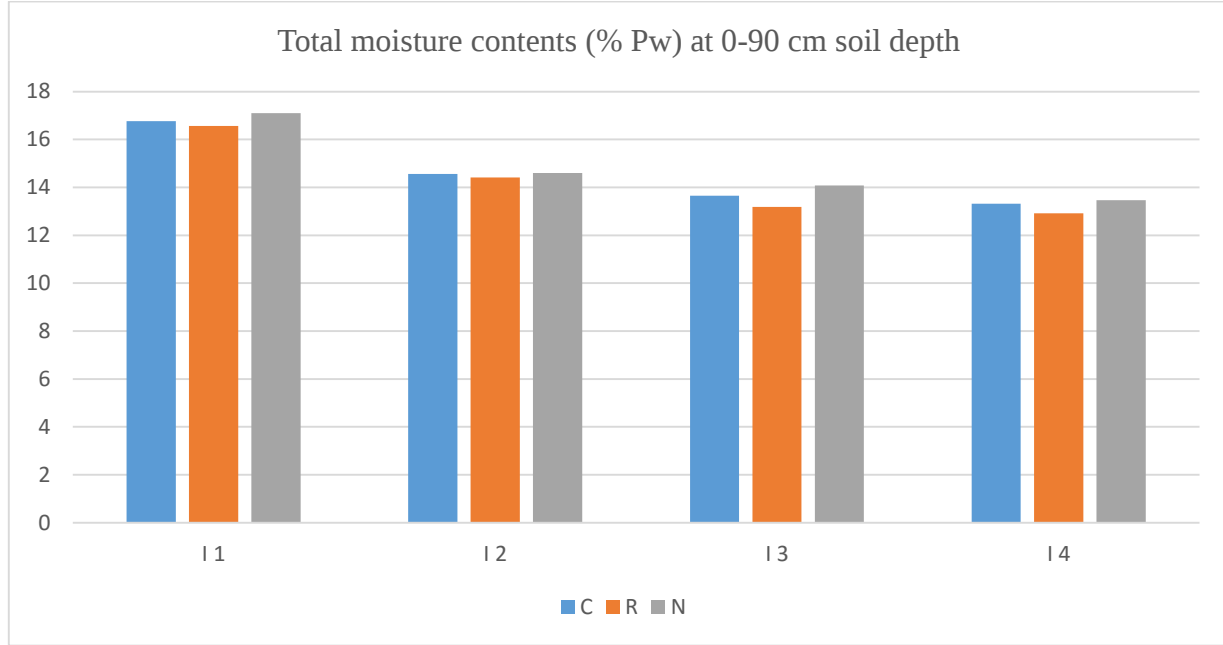


Figure 6. Total moisture contents (% Pw)

Results of 2017 year: The averages of total silage maize yield were found in conventional tillage, reduced tillage and no tillage treatments as 5623, 5927 and 6404 kg/da, respectively (Table 11). Total yield values had affected by full irrigation, 75 % deficit irrigation, 50 % deficit irrigation and 25 % deficit irrigation treatments, and found as 7825, 6617, 5443 and 4054 kg/da, respectively (Table 11). High yield (7825 kg/da) was obtained in full irrigation level, and it was statistically significant ($P < 0.01$). Total yield of 6617 kg/da obtained in I2 irrigation level was also reasonable yield for 2017 year results (Figure 7).

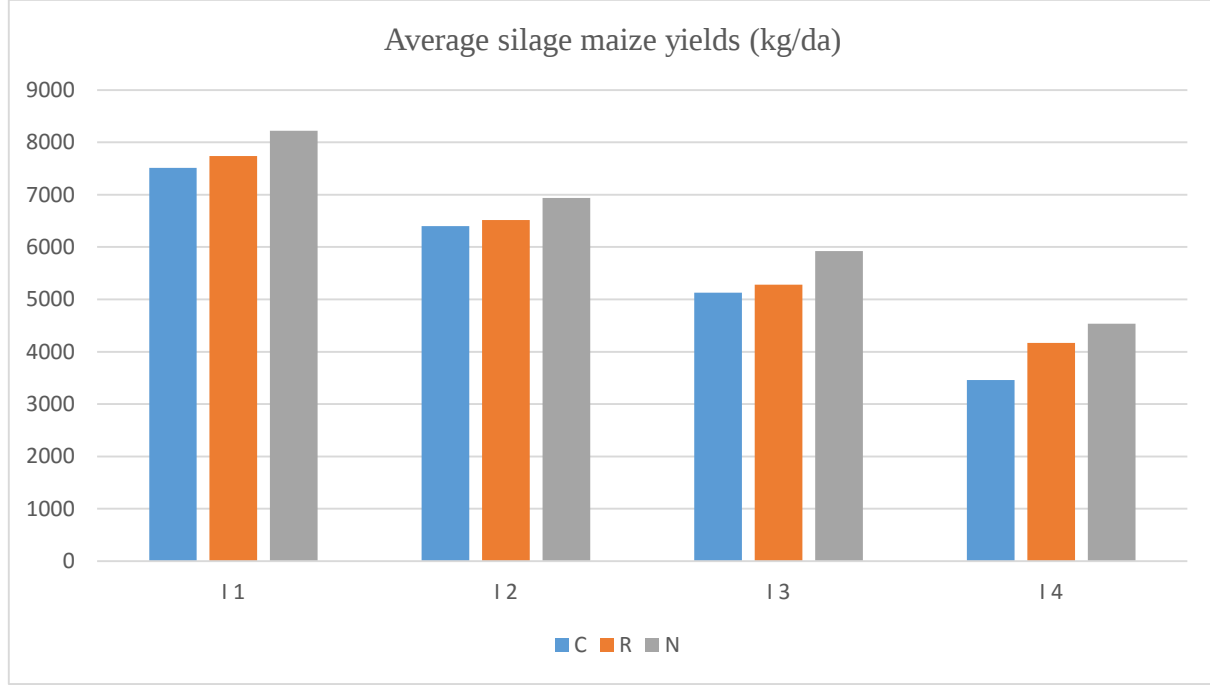


Figure 7. Silage maize yields (kg/da)

The averages of total moisture content (% Pw) at 0-90 cm soil depth were found in conventional tillage, reduced tillage and no tillage treatments as 13,84, 13,92 and 14,25 %, respectively (Table 12). Total moisture content at 0-90 cm soil profile had affected by tillage treatments. Highest moisture content in the soil profile was obtained by no tillage as compared to other tillage treatments for all irrigation applications, and it was found statistically significant ($P<0.01$). Total moisture content values had affected by full irrigation, 75 % deficit irrigation, 50 % deficit irrigation and 25 % deficit irrigation treatments, and found as 17,02, 14,58, 12,51 and 11,90 %, respectively (Table 12). High moisture content (17,02 %) was obtained from full irrigation, and the value was statistically significant at $P<0.01$ level (Figure 8).

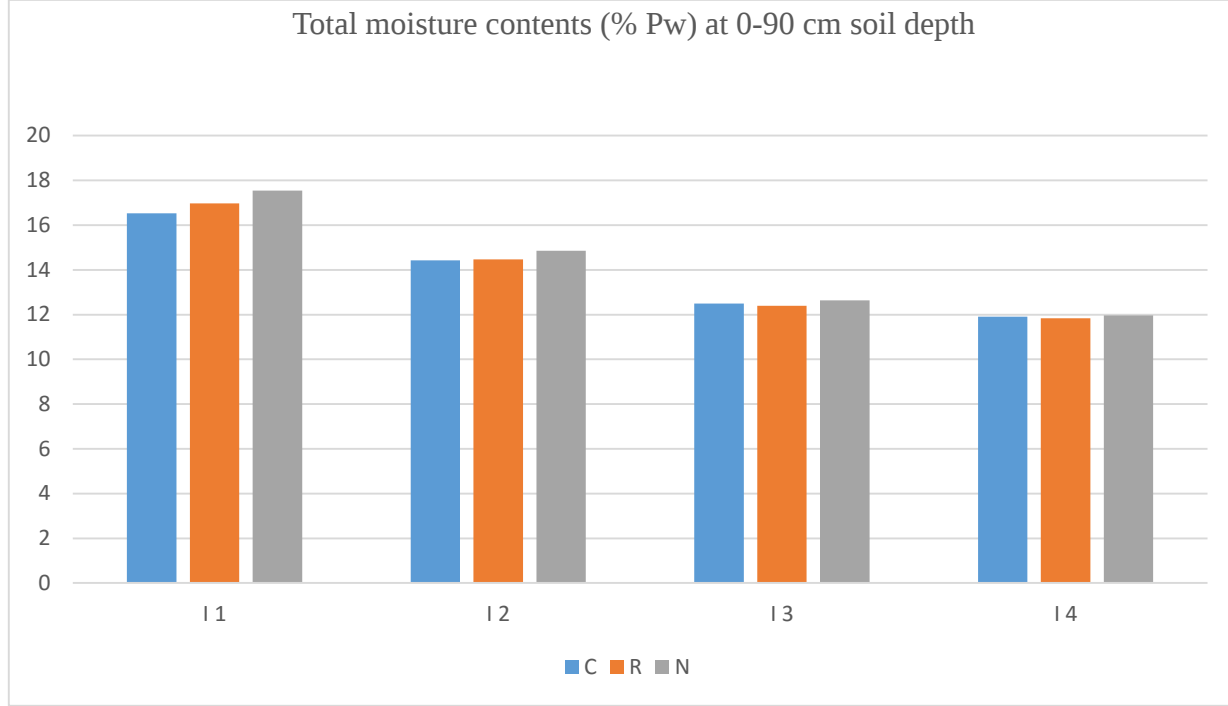


Figure 8. Total moisture contents (% Pw)

5. Conclusion

Animal husbandry has great importance and silage maize is widely used for cattle feeding in the Erzurum region. One of the main aim of experiment was to do irrigation scheduling with right amount and right time of water application to maize which affected to yield increases. Neutron probe was used to measure moisture content of soil, before and after irrigations. Measurements were done at 0-30, 30-60 and 60-90 cm soil depths for the determination of how much applied water reached to the plant root zone, after irrigation. Three year experiment results indicated that no till and 75 % deficit irrigation treatments can be recommended to local producers for economic production of maize. No till practice in all irrigation levels provided to energy save comparing with the other tillage practices. Nilahyane et al. (2018 a) founded that irrigation water, N, and application time significantly affected the growth and dry matter yield of silage maize. According to this research results; 100 ETc and 180 kg N/ha is the best combination for high yielding corn for silage grown in a semi-arid climate under surface drip irrigation. Nilahyane et al. (2018 b) resulted that properly managed irrigation water and nitrogen fertilizer had to increase the biomass and reduce the yield gap of silage corn in the semi-arid region of USA. Zdenek et al. (2017) were found relatively high correlations using precipitation totals for July alone, as this simple indicator explained 64 % of the observed variability in the average

silage yields of maize. Gheysari et al. (2009) stated that the availability of soil moisture effects to N fertilizer uptake of silage maize. Besides, N fertilizer effect should be decreased under drought stress conditions. Gheysari et al. (2017) applied deficit irrigation management strategy to maize crop. They stated that proper irrigation time and irrigation depth strategy was selected for improving the irrigation water use efficiency and also on the development of maize roots. Marakoglu & Carman (2017) founded that the highest energy save management and obtained silage yields were in the no till treatment for Middle Anatolia region. Struck et al. (2019) concluded that no-till maize cropping can contribute to N-fertilizer saving and it could be preferred for fuel saving for silage maize production in semi-arid climate regions located at high altitudes.

6. References

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