Current Trends in Natural Sciences Vol. 5, Issue 10, pp. 93-101, 2016

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

ASSESSMENT OF IRRIGATION EFFICIENCIES UNDER CENTRAL ANATOLIA CONDITIONS

Yusuf Ersoy Yildirim*, İsmail Taş, İlhan Çakmak*****

*Ankara University Agriculture Faculty, Farm Structures and Irrigation Dept., Ankara, Turkey
E-Mail: yey65@yahoo.com
** Canakkale Onsekiz Mart Uni., Faculty of Agriculture, Farm Structures and Irrigation Dept., Canakkale, Turkey
*** Turhish Agricultural Bank, Hasköy Brunch Ankara, Turkey

Abstract
Turkey is located within semi-arid climate zone and large portion of the country experience water deficits. Thus, efficient water use has become a significand issue in agricultural practices. Current global warming and climate change have aggravated such deficiencies. Konya province is located right at the center of Central Anatolia region and mostly groundwater is used in irrigations. Excessive groundwater withdrawals drop groundwaters levels and also increase energy costs. Although farmers pay quite high sums for energy, they were not using water efficiently and thus were not able to get desired benefits from the irrigations. In this study, irrigation practices of an irrigation cooperative were assessed and compared with optimum irrigation programs created through IRSIS irrigation scheduling software. It was concluded that all irrigation practices of the region were wrong and way behind the optimum ones.

Keywords Groundwater, IRSIS, irrigation scheduling, irrigation cooperative

1. INTRODUCTION

Available water resources are quite limited all around the world and in Turkey and there is an ever-increasing pressure over these resources through increased consumptions. According to Fischer and Heilig (1997), 7% of world population was living in water-scarce regions in 1997 and this ratio will increase to 67% by the year 2050 and majority of such an increase will be observed in developing countries. The renewable water potential of Turkey is 112 km^3 and by the end of 2015, 44 km^3 of this potential are being used. Of this utilized portion, more than 70% is used in agriculture. By the year 2030, all of this potential is planned to be used and in this case the amount used in agriculture will decrease to 65%. Such a target will only be achieved through widespread of water-saving pressurized irrigation systems and measured water use (Beyribey et al., 2003). Irrigation system performance includes the following parameters; (i) water distribution homogeneity over irrigated land, (ii) sufficiency of irrigations in meeting plant water requirements, (iii) total amount of available water applied to plant and (iv) leached portion of applied water (Wahdan and El-Gayar 1988).

Kodal (1993) indicated that success of an irrigation cooperative was closely related to a well irrigation planning, water distribution program and implementation of that program. To include

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

engineers, irrigation technical stuff and workers in this success, an irrigation scheduling should be prepared.

Tekinel et al., (2001) reported that farmers used 2-6 times more than the required amounts in GAP irrigation systems. To prevent excessive water use and provide an efficient water use, sufficient amount of water should be supplied at proper times, applied water should definitely be measured at fields, water fees should be based on volume instead of plant-area and farmers should continuously be trained about irrigation and efficient water use.

Kırnak et al, (2013) indicated the major mistakes made in sprinkler irrigation systems of GAP region as wrong sprinkler selection without taking system discharge into consideration, not considering actual plant water requirements in irrigations, longer lateral lines and consequently pressure-discharge variations and non-homogenous water distribution, irrigations at windy durations, improper pump selection and finally unconscious irrigations.

The fluctuations in energy resources and variations in energy costs negative effect the farmers especially in performance of irrigations. Together with unconscious and excessive water use, energy costs are rapidly increasing. Tüzün et al., (2006) investigated the share of energy costs in total production costs for Dicle Kralkızı Right Bank Pumping, Yaylak and Bozova Pumping, Nurdağı-Gedikli Pumping and Viranşehir groundwaters irrigations of GAP region. Required data was gathered from previous studies. The problems experienced in agricultural sector, imbalance between product and input costs, low yield levels, insufficient technology utilization and etc. issues continuously decreased income levels of farmers.

In design and management of irrigation systems, efficient irrigation and maximum water use efficiency have become critical operational goals. Improper irrigation system design, installation or management could be the reason for irrigation inefficiency. By quantifying performance of irrigation methods, guidelines could be developed to improve their design and management. Maximizing the fraction of water productively used by the crop was considered to be a first step towards the goal of increasing sugar yield per unit of water and maximizing the economic return on capital invested in irrigation systems (Magwenzi, 2000).

Irrigation efficiency is a measure of the effectiveness of irrigation. It is a parameter which defines irrigation performance. Various definitions of irrigation efficiencies have been developed (Israelsen et al., 1944; Jensen, 1967; Bos, 1985; Jensen, 1993). Israelsen et al. (1944) defined water application efficiency as the "ratio of the amount of water that is stored by the irrigator in the soil root zone and ultimately consumed (transpired or evaporated or both) to the amount of water delivered to the farm." The American Society of Civil Engineers' (ASCE) on-farm irrigation committee (Kruse, 1978) has defined on-farm irrigation efficiency as the ratio of the volume of water that is taken up by the crop to the volume of irrigation water applied (Ahadi et.al., 2013)

Irrigation is an essential input in agricultural production and expected benefits can only be achieved through proper implementations. Such proper implementations also allow efficient use of all the other inputs. Possible wrong implementations both negatively affect the other inputs and result in serious environmental problems. Expert stuff should be employed in irrigation planning, monitoring and assessments. The present study was conducted to compare current irrigation practices of an irrigation cooperative using groundwaters in irrigations and growing wheat, maize and sugar beet with optimum irrigation practices.

2. MATERIALS AND METHODS

Research site and climate

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521
Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

The present research was conducted in Alibeyhüyüğü irrigation cooperative located within the boundaries of Çumra town of Konya province. The cooperative is 40 km away from the city center (Figure 1). The cooperative uses groundwaters as water resource for irrigations. Groundwater is withdrawn with electric pumps and distributed to irrigation network through pressurized pipes. The SCADA system is used in irrigation network. Producers pre-pay irrigation fees based on well discharges. In other words, producer deposit the amount of water needed into his irrigation card and receive the water through inserting his card into the system in his field.

Four pilot plots with a size of 58, 26, 11 and 5 da were selected from the irrigation fields of the cooperative (Table 1). Then, irrigation records of these plots for the years 2011, 2012 and 2013 were received from the cooperative.

Figure 1. Irrigation Districts of Alibeyhüyüğü Irrigation Cooperative

Table 1. Crops produced in selected plots of Alibeyhüyüğü Irrigation Cooperative

Area (da)	2011	2012	2013
58	Maize	Maize	Wheat
26	Maize	Maize	Sugar beet
11	Sugar beet	Wheat	Maize
5	Sugar beet	Wheat	Maize

A climate station is not available in irrigation district of the cooperative. However, there is a climate station in Çumra town 10 km away from the research site and the station is able to represent the region. Therefore, climate data was supplied from this station. Long-term averages for some climate parameters are provided in Table 2. As it was seen from the table, the region has terrestrial climate with hot and dry summers and precipitated and cold winters.

Irrigation scheduling for the crops over selected plots was performed with IRSIS (Irrigation Scheduling Information System) software. Reference evapotranspiration (ETo) values for pilot plots were also calculated by using ASCE Penman-Monteith (ASCE-PM) method and crop coefficients were taken from previous studies carried out in the region and actual evapotranspiration (ETc) values were calculated.

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

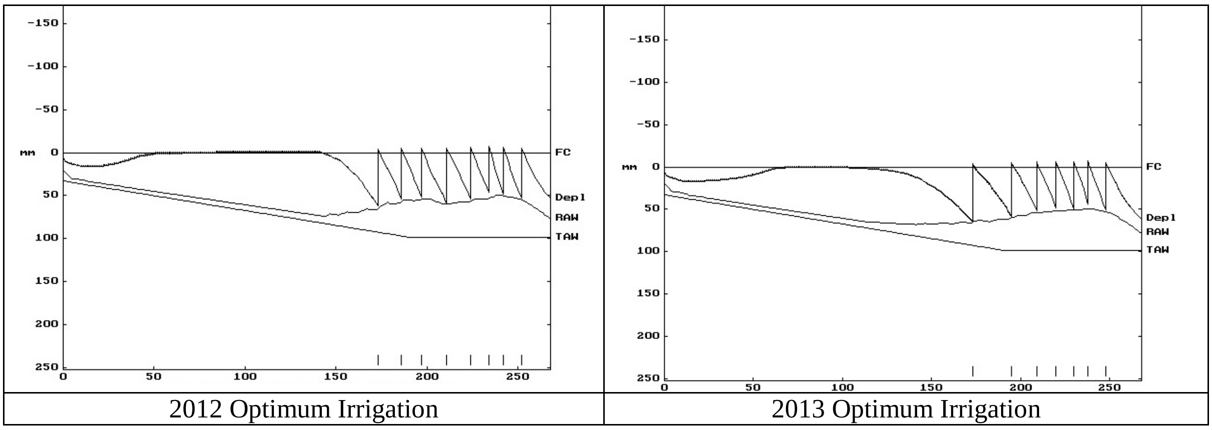
Table 2 Long-term averages for some climate parameters

Latitude: 37°35'	Longitude: 32°47'		Altitude: 1013 m			
Months	Average Min. Temp. °C	Average Max. Temp. °C	Average Relative Humidity (RH) (%)	Sunshine Duration (n) (hour:min/day)	Average Wind Speed (U) (m/s)	Precipitation (mm)
1	-4	4.9	77	03:36	0.8	36.8
2	-3.4	6.6	72	05:21	1.1	28.5
3	-0.3	12	65	06:18	1.1	32.9
4	4.7	17.9	60	07:07	1.1	44
5	8.5	22.4	60	09:13	0.9	39.2
6	11.9	26.8	55	10:36	0.9	19
7	14.6	30.2	51	11:25	1	5.9
8	13.9	30	52	11:26	0.7	3.3
9	9.8	26.5	55	09:48	0.6	7.5
10	5.5	20.1	64	07:21	0.5	31.6
11	0.8	12.6	72	04:06	0.8	35.3
12	-2.1	6.6	77	03:09	0.8	42.5
Avr.	5	18.1	63	07:27	0.9	326.5

3. RESULTS and DISCUSSIONS

Current Irrigation Practices

To assess the irrigation performed on pilot plots of Alibeyhüyüğü Irrigation Cooperative, data on irrigation durations and well discharges were received from cooperative records and used in IRSIS program. The results of IRSIS software for each year are presented in Figures 2, 3 and 4. Figures revealed that current irrigations were all made wrongly. Irrigations were found to be insufficient, but excessive water was applied in each irrigation. Despite excessive water supply, plants were exposed to water stress resulted from deficit irrigations. Severity and duration of stress resulted in losses in yield and quality.



2012 Optimum Irrigation	2013 Optimum Irrigation

Figure 2. Number of irrigations and variations in soil moisture profile for wheat

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

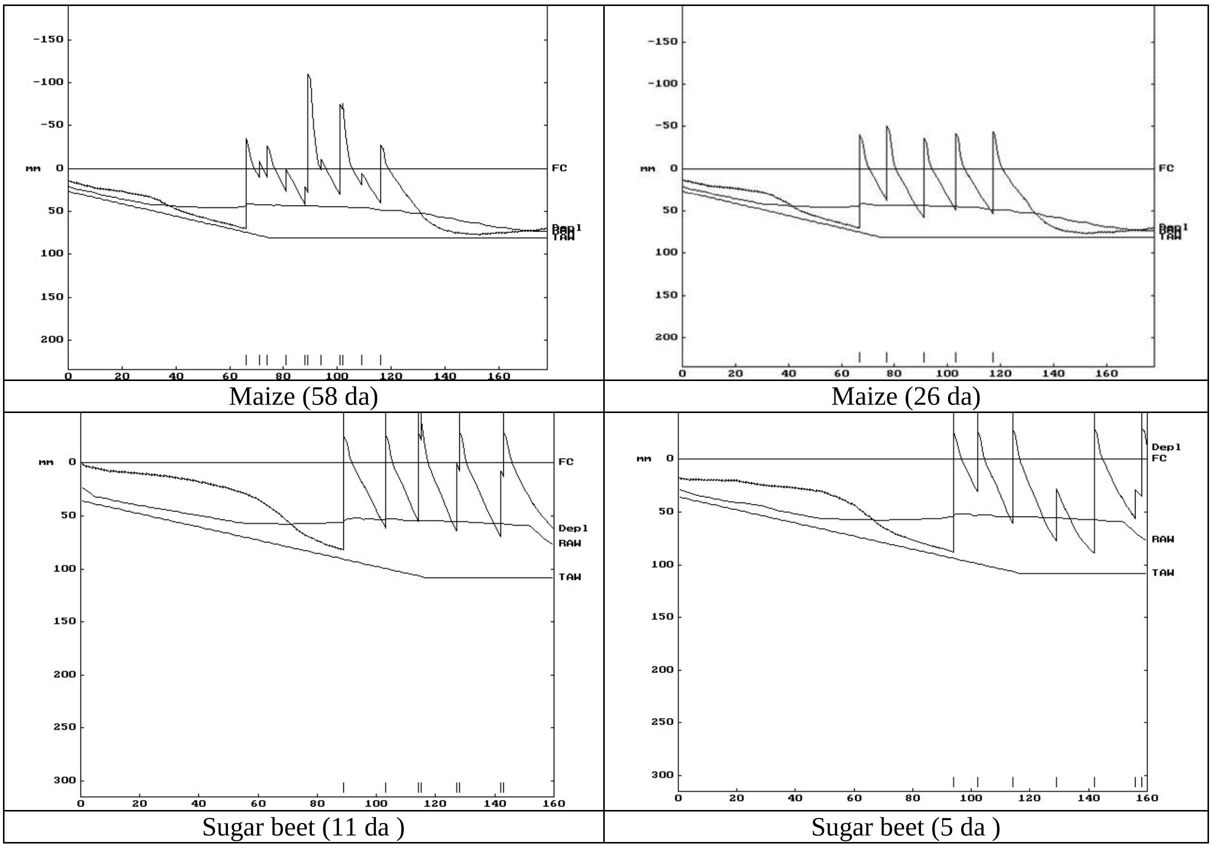


Figure 3. Irrigations and variations in soil moisture in 2011

Table 3. Amount of total applied irrigation water and optimum irrigation water amounts

Years	Area (da)	Crop	Methods of Irrigation	Total Applied (mm)	Requirement (mm)
2011	58	Maize	Flood	554.8	571.3
2011	26	Maize	Flood	478.1	571.3
2011	11	Sugar beet	Sprinkler	1085.1	561.9
2011	5	Sugar beet	Flood	1136.9	561.9
2012	58	Maize	Flood	975.1	667.3
2012	26	Maize	Flood	616.2	667.3
2012	11	Wheat	Sprinkler	234.6	468.1
2012	5	Wheat	Flood	566.0	468.1
2013	58	Wheat	Sprinkler	414.3	400.3
2013	26	Sugar beet	Sprinkler	576.6	663.7
2013	11	Maize	Flood	987.5	643.5
2013	5	Maize	Flood	822.0	643.5

Optimum Irrigation Practices

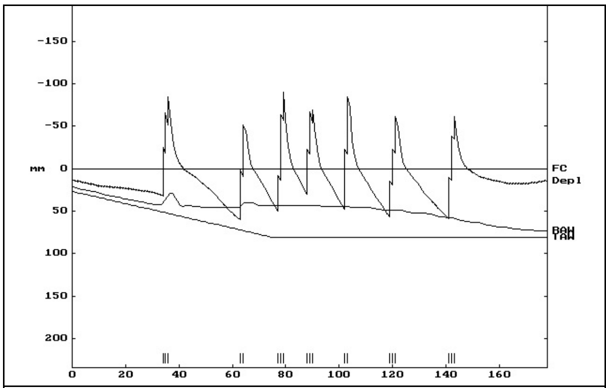
Irrigation program for wheat irrigation in production years is presented in Figure 5. A total of 8 irrigations are required for wheat in 2012. The number decreased to 7 in 2013. As it can be seen from Table 3, wheat total irrigation water requirement was 468.1 in 2012 and the value decreased to 400.3 mm in 2013. Maize optimum irrigation and soil moisture profile are presented in Figure 6. Number of irrigations for maize was 12 in 2011, 15 in 2012 and 14 in 2013. Maize irrigation water requirement was 571.3 mm in 2011, 667.3 mm in 2012 and 643.5 mm in 2013. Sugar beet optimum

Current Trends in Natural Sciences Vol. 5, Issue 10, pp. 93-101, 2016

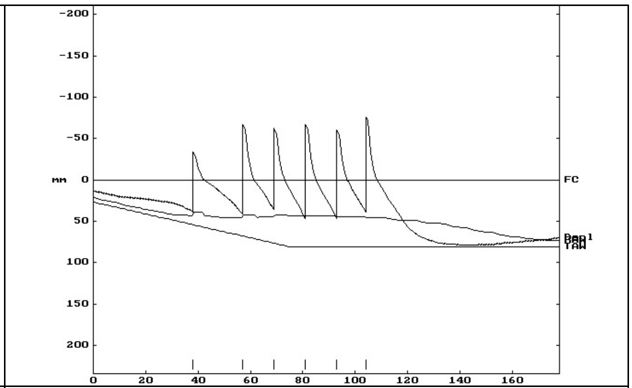
Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

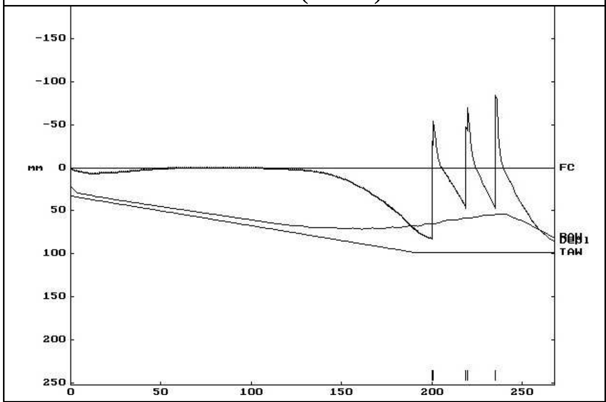
irrigation and soil moisture profile are presented in Figure 7. Number of irrigations for sugar beet was 10 in 2011 and 12 in 2013. Sugar beet irrigation water requirement was 561.9 mm in 2011 and 663.7 mm in 2013.



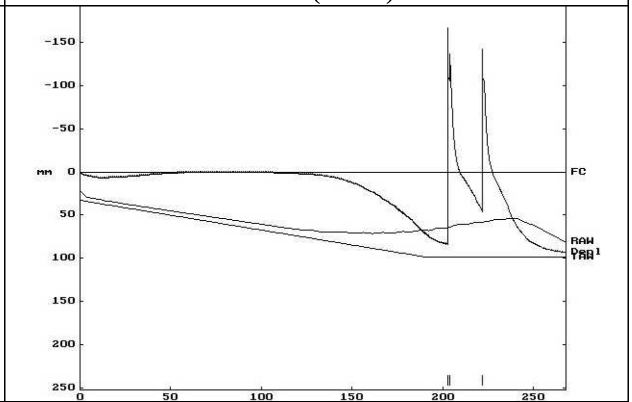
Maize (58 da)



Maize (26 da)

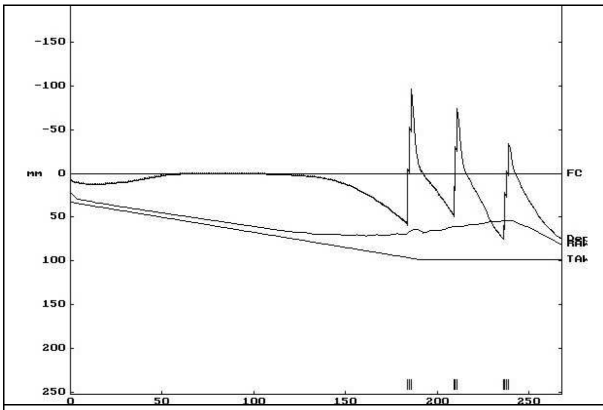


Wheat (11 da)

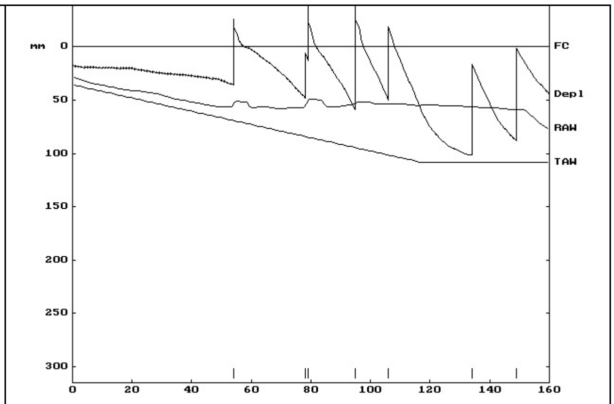


Wheat (5 da)

Figure 4. ***Irrigations and variations in soil moisture in 2012***



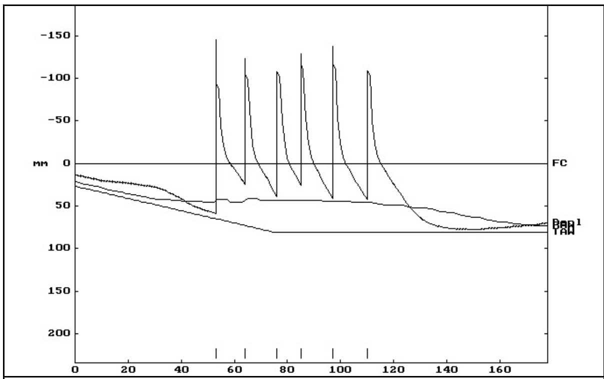
Wheat (58 da)



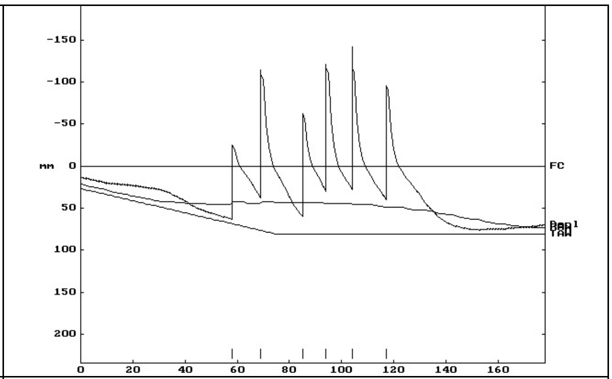
Sugar beet (26 da)

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

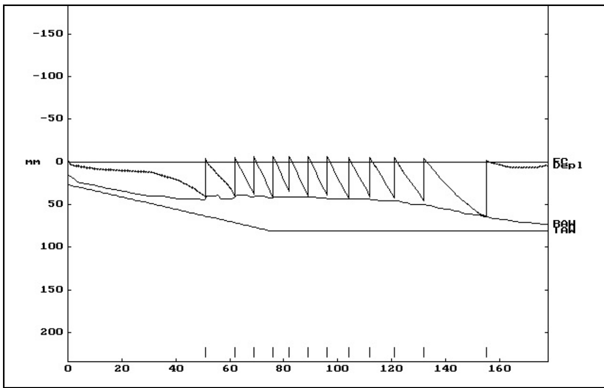


Maize (11 da)

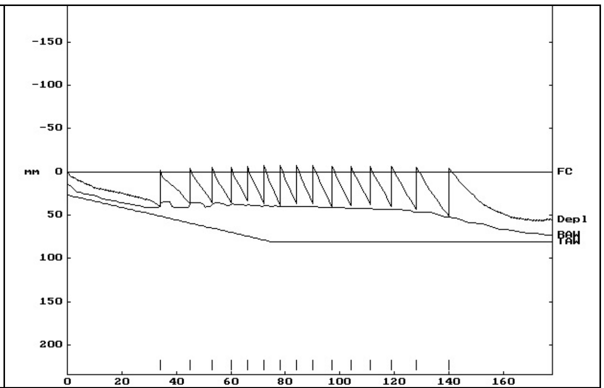


Maize (5 da)

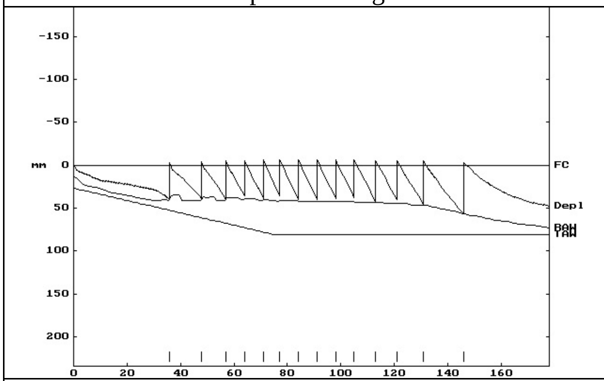
Figure 5. Irrigations and variations in soil moisture in 2013



2011 Optimum irrigation



2012 Optimum irrigation

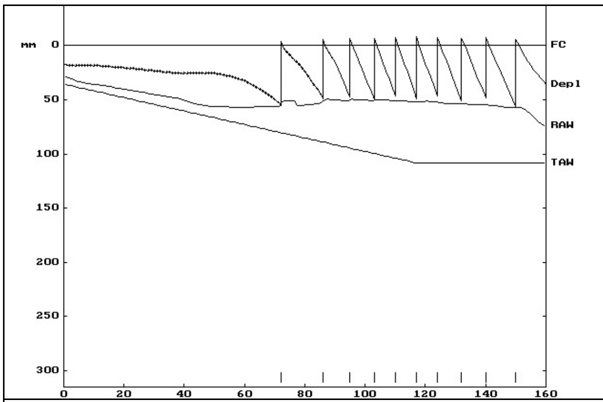


2013 Optimum irrigation

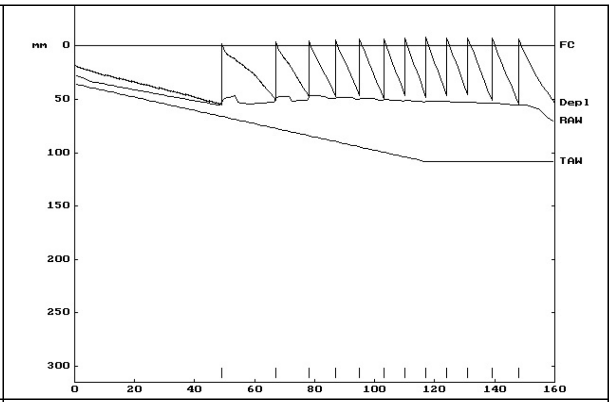
Figure 6. Maize optimum irrigation and soil moisture profile

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521



2011 Optimum irrigation



2013 Optimum irrigation

Figure 7. Sugar beet optimum irrigation and soil moisture profile

4. CONCLUSIONS

A general assessment about the performed irrigations revealed that the maize irrigation over 26 da in 2012 was the closest irrigation to optimum. Total applied irrigation water was calculated as 616.2 mm while the required amount was calculated as 667.3 mm. However, flooding irrigation was used to apply the required amount. The irrigation efficiency is between 20-50% in flooding irrigation (Bauder et al., 2014). As it was in Figure 3, almost half of the applied irrigation water was lost through either runoff or leaching. In other words, only 308.1 mm of the applied water was used. That corresponds to 43.17% of the required amount and ultimately means 50% deficit. Optimum irrigation graph revealed that about half of the total number of irrigations was performed.

Expected yield and quality increases in irrigated farming can only be achieved through proper irrigation programs compiling irrigation water quality and quantity, climate conditions, crop requirements and soil characteristics-like parameters together. All irrigation practices over the research site were wrong and there were significant losses. Excessive irrigation was observed almost all of the irrigations. Producers applied the amounts quite above the soil storage capacities. These excessive amounts in long run may result in drainage and salinity problems. Such excessive amounts may also leach plant nutrient below the root zone. Such leaching may then create pollution in surface and groundwaters resources. Excessive irrigation water also increases the energy use and thus increase irrigation and production costs and reduces competitive power of the producers. It should always be kept in mind that proper irrigation programs had the key role in agricultural production activities.

5. REFERENCES

Ahadi, R., Samani, Z., Skaggs, R. (2013). Evaluating on-farm irrigation efficiency across the watershed: A case study of New Mexico’s Lower Rio Grande Basin. *Agricultural Water Management, 124*, 52–57.

Bauder, T.A., Waskom, R.M., Andales, A. (2014). *Nitrogen and Irrigation Management.* Crop Series Soil. Fact Sheet No. 0.514. Colorado State University Extension. 3/99.

Beyribey, M., Kodal, S., Yıldırım, Y.E. ve Erdoğan, F.C. (2003). Su Yönetiminde Sulama Teknolojilerinin Önemi, Sulama Sistemleri Sempozyumu ve Sergisi, Aralık.

Bos, M.G. (1985). Summary of ICID definitions on irrigation efficiency. *ICID Bulletin 34 (1)*, 28–31.

Jensen, M.E. (1967). Evaluating irrigation efficiency. *Journal of the Irrigationand Drainage Division American Society of Civil Engineers, 93* (IR1), 83–98.

Fischer, G., Heilig, G.K. (1997). Population Momentum and The Demand on Land and Management. *Journal of Irrigation and Drainage Engineer, ASCE, 121 (1)*, 71.

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

Israelsen, O.W., Criddle, W.D., Fuhriman, D.K., Hansen, V.E. (1944). Water appli-cation efficiencies in irrigation. Agricultural Experiment Station Bulletin 311.Utah State Agricultural College, 55p, available online at: http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1272&context=uaes bulletins

Jensen, M.E. (1993). *Impacts of irrigation and drainage on the environment.* In: FifthGulhati Memorial Lecture. Proceedings of the 15th ICID Congress, The Hague, Netherlands.

Kırnak, H., Demir, S., Taş, İ. (2013). GAP-Şanlıurfa İli Bireysel Yağmurlama Sulama Sistemlerinin Performans Göstergeleri. Akdeniz Üniversitesi Ziraat Fakültesi Dergisi, 26(1), 41-48.

Kodal, S. (1993). Su Bütçesi Yaklaşımının Ülkemizde Ş.Pancarı Sulama Zamanı Planlamasına Uygulanması. Toprak su 1993-1, s.2-8, Ankara.

Kruse, G. (1978). Describing irrigation efficiency and uniformity. *ASCE Journal of theIrrigation and Drainage Division 104 (1),* 35–41.

Magwenzi, O.E. (2000). Evaluation of irrigation efficiency in the swaziland sugar industry. *Proc S Afr Sug Technol Ass, 74.*

Tekinel, O., Kanber, R., Ünlü, M., Topaloğlu, F. (2001). Güneydoğu Anadolu Proje Alanlarında Sulama Suyu Kullanımının Değerlendirilmesix 1.Ulusal Sulama kongresi, s. 33-37, Antalya.

Tüzün, A. M., Kodal, S., Demir, H., Bilgen, G.K., Baysan, N. (2006). Gap Sulamalarında Enerji Maliyetinin Ürün Maliyeti İçerisindeki Payı. TMMOB Su Politikaları Kongresi, s. 411.

Wahdan, A.A., El-Gayar, A.M. (1988). Spatial distribution of irrigation water application in sprinkler irrigation. American Society of Agricultural Engineers, Paper No. 882620.