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A research on site specific irrigation in irrigated maize in Cukurova region for energy and water saving

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Abstract

The effective use of agricultural input is only possible when spatial variability is recognized in the field by using information and precision farming technology then managed according to it. Effective and productive plant production requires the most appropriate water application strategies that take soil, climate, and farming operations into account. In addition to this, inputs used must be applied to where it is required without giving any harmful effects to the environment. In this study, spatial soil texture maps were created. Based on this soil maps, a total available water map was developed. According to the available water distribution map in the field, a variable rate water application map was produced in real farming data. Based on these variable rate water application maps, an economic evaluation was made to see the potential of energy and water savings. An estimation of the total water and energy saving in Adana, Çukurova has shown very promising results. According to evaluation of site specific irrigation for 38,8 ha maize field irrigation in Adana, Çukurova, 5.3% water saving which is equal to 847 m^3 was possible for the 2009 irrigation season. It is also proved that using site specific irrigation technique offers a considerable energy saving with 3661 to 8106 toe (tons of oil equivalent) according to different irrigation scenario for the 125000 ha field for maize in Adana, Çukurova.

*Keywords: S*ite specific irrigation; Variable rate irrigation; Energy and variability management
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1. Introduction

Irrigation is one of the most important applications during the cultivating season. Site specific or precision irrigation, is a relatively new concept in agriculture. Precision irrigation is the term used to describe those systems that are able to deliver differential amounts of water to different areas of the field [1]. Site specific irrigation is based on the assessment of the water requirements based on the texture of the soil [2]. Additional factors are field topography, plant numbers, nutrients and yields. Once the water application prescription maps

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are formed appropriate equipment are required to do the application. The economic and environmental benefits of improving the volumetric efficiency of irrigation are obvious, in both the value of the water and energy saved and the additional production possible with this water. It is also assumed that yield will be maximized if each plant is supplied with water exactly matching its individual requirements [3, 4].

Normally, the farmers apply the maximum water amount on the whole field when they irrigate. In site specific Irrigation practice, the field is divided into management zones and in each zone is applied the appropriate irrigating water amount. Increase number of researchers has started studying site specific irrigation to achieve water and energy saving purposes on self-propelled irrigation systems [5-9].

2. Material and methods

This study was carried out in Adana province, Yolgecen village, Bulduk location, 36^0 57^1 49 N, 035^0 08^1 08 E (as UTM 36 690 155 E, 4093154 N) in Cukurova region comprising an area of approximately 38.8 ha (Fig. 1). The field was planted with maize grown in irrigated condition. Soil sampling was conducted. The soil analysis data were processed by GIS software, exporting soil texture maps. The three texture maps, clay, sand, silt, are shown below (Fig. 2).



Fig. 1. The air view of study field.

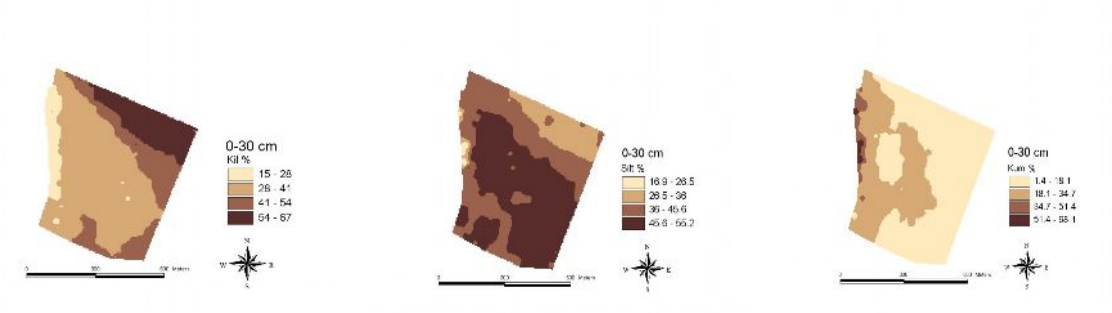


Fig. 2. Soil clay, silt and sand content variability map of Bulduk field in Adana in 2009 (from left to right).

2. 1. Management zone delineation

All data were processed by Management Zone Analyst (Version 1.0) software program, which uses fuzzy logic algorithms to divide data into groups. All data in each group have common properties. Hence, the field is divided into zones. The experimental field was divided into 4 zones. Each zone has different soil properties and therefore the irrigation needs for each zone ranges. Zone map is shown in Fig. 3.

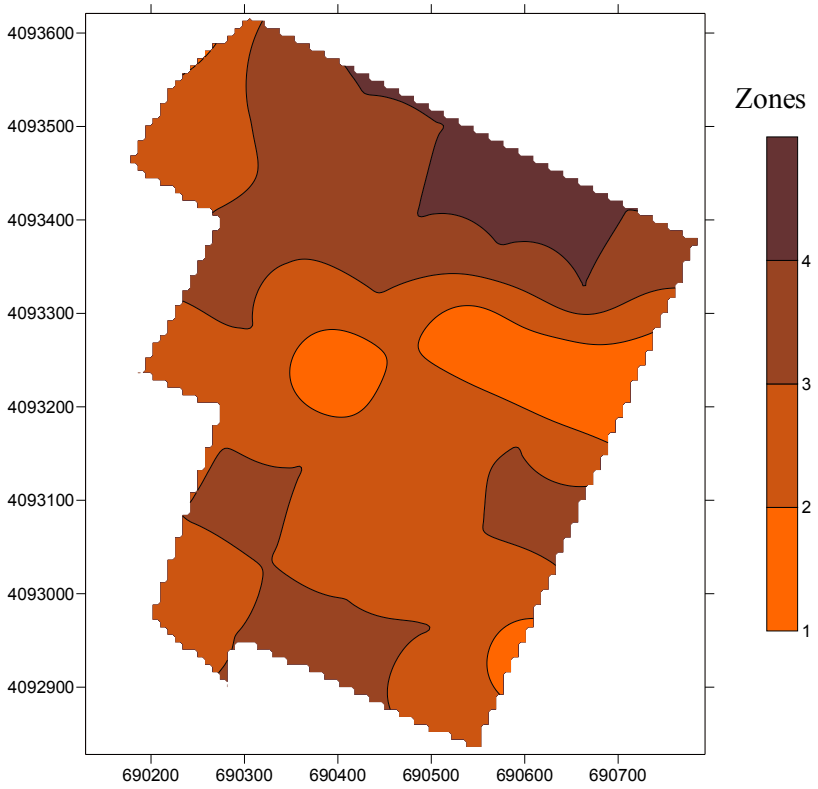


Fig. 3. Soil zone map for input management

According to the zone map, zone 2 and zone 3 covers more than 75% of the experimental field. Table 1 shows the percentage of coverage and the area size for each zone.

Table 1. Zone area size and zone coverage as percentage of total field

	Zone-1	Zone-2	Zone-3	Zone-4	total
Area size (ha)	6.4	18.3	11.5	2.6	38.8
Coverage %	16.5	47.2	29.7	6.6	100

2. 2. Irrigation data processing and developing spatial available water map

CROPWAT Version 8.0 (software developed by FAO) was used to calculate irrigation needs for each zone. As input the program needs:

- Climate data - collected from National Meteorological Service.
- Rainfall data - collected from National Meteorological Service.
- Crop data
- Soil data - soil texture values (Table 2) were inserted into a program (recommended by FAO-CROPWAT) which calculates the total available soil moisture.

As output the program gives:
- Crop water requirements
- Crop irrigation schedule

All data collected from the experimental fields, were inserted into CROPWAT software. Soil properties differ for each zone. Consequently the program was run four times, one for each zone.

According to soil texture class, the mean total available water values (the sunflower effective root depth is 90 cm) were calculated for 90 cm depth (maize effective root depth) and available spatial water map was created (Fig. 4).

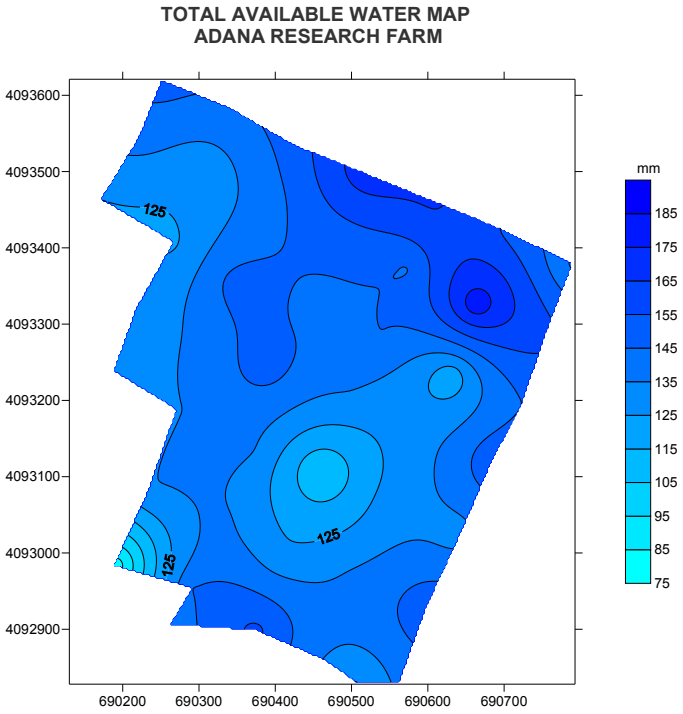


Fig. 4. Developed total available spatial water map

3. Results and discussion

According to total available water, the total irrigation water map was created on top of total available water (Fig. 5). A total 6 irrigation number obtained for each soil texture zone.

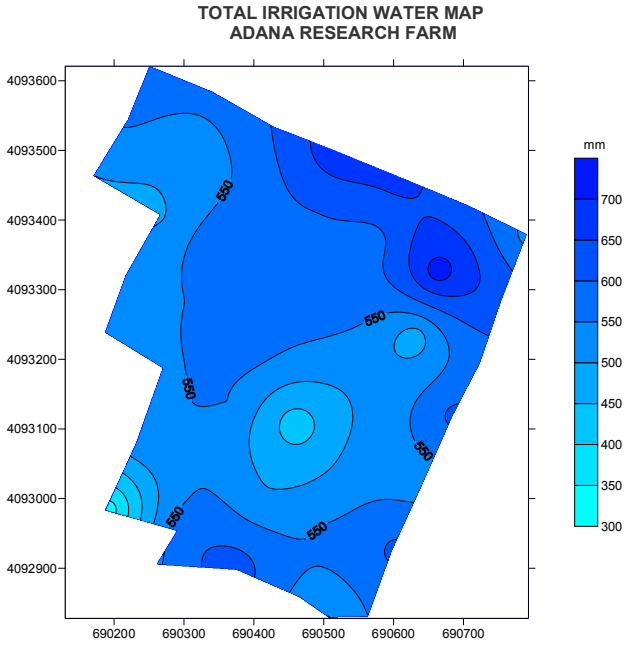


Fig. 5. Total site specific irrigation application water map.

The difference between total irrigation water amounts for the two methods results the amount of water that is being saved if VRI system is applied. Therefore, if a VRI system is applied on the 38.8 ha experimental field 847 m^3 of water are saved which refers to 5.3% reduction (Table 2).

Table 2. Irrigation water calculations for the four zones scenarios.

	Zone-1	Zone-2	Zone-3	Zone-4	Total
Area size (ha)	6.4	18.3	11.5	2.6	38.8
Total net irrigation (mm)	315	385	415	547	
V. R. irrigation water amount (m^3)	2016	7045	4772	1422	15,255
Conventional irrigation water amount (m^3)					16,102
Water saving (m^3)					847
Water saving (%)					5.3

The following results (Table 3) estimate the energy consumption for different scenarios. A water application at 5,000 m^3/ha is taken to estimate the energy consumption as a product of pressure and discharge divided by the efficiencies. Assuming a 125,000 ha of irrigated land and 5% water saving in Adana region the total energy requirement is given in Table 3.

Table 3. Energy consumption and energy saving when using Site specific irrigation Analysis for 4 different irrigating scenarios in Adana, Çukurova

Irrigation scenarios	Total manometric height (Pa)	Pressure load including losses in pump*	Including losses in electric motor**	Electricity consumption in joule to deliver 1 m^3 of water to 1 ha***	Water applica tion m^3/ha	Specific pumping energy MJ/ha	Irrigated area Cukurova (ha)	Total energy requirement (MJ)	Toe****	Energy saving by 5% water saving (Toe)
Traveller irr+ramp+pd 10	686,700	981,000	1,090,000	4,905,000	5000	24,525	125,000	3,065,625,000	73,221	3661
Traveller irr+ramp+pd 70	1,275,300	1,821,857	2,024,286	9,109,286	5000	45,546	125,000	5,693,250,000	135,981	6799
Traveller irr+rsprinkler+pd 10	931,950	1,331,357	1,479,286	6,656,786	5000	32,328	125,000	4,041,000,000	96,518	4826
Traveller irr+rsprinkler+pd 70	1,520,550	2,172,214	2,413,571	10,861,071	5000	54,305	125,000	6,788,125,000	162,132	8107

* Pump efficiency 70%
** Electric motor efficiency 90 %
*** 1 joule is equivalent to $2.78.10^{-7}$
**** tons of oil equivalent.

4. Conclusion

The knowledge of soil variability within a field is fundamental to the development of site-specific irrigation management areas since different soils have different available water capabilities. Managing field for irrigation according to this differences offer water and energy saving [10-14]. An estimation of the total water and energy saving in Bulduk field in Adana, Çukurova has shown very promising results. According to evaluation of site specific irrigation for 38.8 ha maize field irrigation in Adana, Çukurova, 5.3 % water saving which is equal to 847 m^3 was possible for the 2009 irrigation season. It was also proved that using site specific irrigation technique offers a considerable energy saving. Analyses for 4 different irrigation scenarios for maize growing have shown that, the final water saving was varying with 3661 to 8107 toe (tons of oil equivalent) from 5 % water saving for irrigation of 125,000 ha in Çukurova region.

References

[1] Turker U, Erdem T, Tagarakis A, Mitev G, Akdemir B, Gemtos TA. A feasibility study of variable rate irrigation in Black Sea area: Water and Energy saving from the application. J Inf Technol Agric (JITAg) 2011;4:1-8.
[2] Al-Karadsheh, E., H. Sourell, and R. Krause. Precision Irrigation: New strategy irrigation water management. Conference on International Agricultural Research for Development. Deutscher Tropentag 2002; Proc., October 9-11. Witzenhausen, Germany, 2000.
[3] Smith, R.J. and Raine, S.R. A prescriptive future for precision and spatially varied irrigation. Nat. Conf. Irrigation Association of Australia, May 22-25, 2000, Melbourne, 2000.
[4] Smith RJ, Raine SR, McCarthy SR. Managing spatial and temporal variability in irrigated agriculture through adaptive control. Austr J Multi Eng 2009;7:79-90.
[5] Turker U. A mechatronic approach to develop a robotic sprinkler head for precision irrigation. In Proc.7th International Congress on Agricultural Mechanisation and Energy (ICAME), Adana, pp. 398-403, 1999.
[6] Evans RG, Buchleiter GW, Sadler EJ, King BA, Harting GB. Controls for precision irrigation with self-propelled systems. In Proc. 4th Decennial National Irrigation Symp., R. G. Evans, B. L. Benham, and T. P. Trooien (eds.), ASAE, St. Joseph, MI, pp. 322-331, 2000.
[7] Klocke NL, Hunter Jr. C, Mahbud A. Applications of a linear move sprinkler system for limited irrigation research. ASAE Paper No. 032012. ASAE Annual International Meeting. July 27-30, Las Vegas, Nevada: ASAE, 2003.
[8] Ohyama K, Murase H, Yokoi S, Hasegawa T, Kozai T. A precise irrigation system with an array of nozzles for plug transplant production. Trans ASAE 2005;48:211-215.
[9] Rodriguez-de-Miranda, F. A site-specific irrigation control system. ASAE Paper No. 031129. ASAE Annual International Meeting. July 27-30. Las Vegas, Nevada: ASAE, 2003.
[10] Demirbas A. High quality water supply for the production of algae. Energy Educ Sci Technol Part A 2011;27:467–476.
[11] Saygi H, Sari N. Effects of different sowing times and plant densities on bolting, yield and bulb parameters in onion. Energy Educ Sci Technol Part A 2011;28:427-444
[12] Kocaer M, Ahiskali A. Importance hydropower resources of Turkey. Energy Educ Sci Technol Part A 2011;27:395–400.
[13] Bakis R. An investigation of small hydropower potential from multipurpose dams in the Porsuk River Basin. Energy Educ Sci Technol Part A 2011;27:105–122.
[14] Kalipci E, Ozdemir C, Sahinkaya S. Evaluation of manageable biological waste utilization of Konya in terms of environment and energy recovery. Energy Educ Sci Technol Part A 2011;27:35–42

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