Agronomy Research **14**(3), 959–966, 2016

Mapping of some soil properties due to precision irrigation in agriculture

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Abstract. Precision Agriculture (PA) is a whole-farm management approach using information technology, satellite positioning (GNSS) data, remote sensing and proximal data gathering. These technologies have the goal of optimizing returns on inputs whilst potentially reducing environmental impacts. This study was conducted out to determine the acidity, salinity, field capacity, permanent wilting point and water holding capacity in precision agriculture by analyzing soil samples taken from the field in 32 points. Maps were drawn by obtaining data from the field. The purpose of this research is to use the geographic information system for comparing the obtained data from soil more quickly and easily than before and also the water amount in order to make precise decisions for agriculture progress and applying the appropriate inputs which is related to water. The present results also indicated that water holding capacity maps. These maps are usage for the irrigation management and the information from different points of the field. These data obtained the field has an important role in the management of precision agriculture.

Key words: Precision Agriculture, Precision Irrigation, Field capacity, Wilting point.

INTRODUCTION

Precision agriculture has mostly emphasized variable-rate nutrients, seeding, and pesticide application, but at several research sites, variable-rate irrigation equipment has been developed to explore the potential for managing irrigation spatially. One goal of precision agriculture is to apply only the optimum amount of an input. While conditions could exist for which the entire field's optimum input is greater than the amount usually applied in a conventional, whole-field mode, most participants expect a reduction in input use on at least parts of fields, if not a reduction in the value aggregated over entire fields (Sadler et al., 2005).

Its meaning in the irrigation industry connotes a precise amount of water applied at the correct time, but uniformly across the field (Evans et al., 2000).

While giving more water than necessary to the field increases leaked water or runoff, giving less water than calculated is defined as deficit irrigation. Both condition is wrong fort the right irrigation. Runoff leaving the field represents waste of water. Either way, the field is also subject to sediment and nutrients moving with the runoff. Precision irrigation, an existing aspect of precision agriculture just beginning to be explored, means applying water in the right place with the right amount. The use of precision agriculture for irrigation water management is still in the development stage and requires a lot of investigation and experimental work to determine its feasibility and applicability (Al-Karadsheh et al., 2001). The last issue of the operation phase of Precision agriculture is variable rate application technology which finds maximum application widely used in Fertilizers, pesticides, irrigation and tillage practices variable rate application technology (Güler & Kara, 2005). A study was conducted to present the benefits and advantages brought by combined use of Factor Analysis and GIS in planning and management of precision agriculture implementations. Precision agriculture represents the approaches allowing the implementation of environment-friendly methods and techniques in agricultural production activities. Parallel to developments in global positioning systems (GPS), farmers have started to be aware of the advantages brought by the implementations carried out in agriculture through considering the spatial differences (Temizel et al., 2015).

A study in Nitra in Slovak Republic, about the effects of precision agriculture was investigated. As compared to conventional water application, precision irrigation contributed to water saving in the amount of 478.56 m^3 ha^{-1}. The electric power saving reached 249.68 $kWh.ha^{-1}$. The cost saving was characterized by the value of 9.1 EUR ha^{-1} and this represented 23.8%. The results have shown that precision irrigation is a fully effective system of precision farming (Jobbágy et al., 2011).

Precision irrigation as an aspect of precision agriculture, is a relatively new concept in irrigation farming worldwide (Temizel & Koç, 2015). It involves the application of irrigation water in optimum quantities over an area of land which are not uniform and has variations in soil type, soil water capacity, potential yield and topography. Precision irrigation provides a sustainable agricultural system which uses resources efficiently and develops and maintains the actual water demands (Temizel et al., 2014). Precision agriculture is a knowledge-based technical management system which should optimise farm profit and minimise the impact of agriculture on the environment (Dennis & Nell, 2002).

This study aims to show how to save a limited amount of available water through precision agriculture.

MATERIALS AND METHODS

Material

Land and Climate Policy

This study was carried out in Samsun 19 May University, Faculty of Agriculture experiment area. Workspace is approximately 5.5 hectares. Samsun prevails ‘type of humid temperate climate’. February is the lowest monthly average temperature month as 6.6 °C and the warmest month is August as 23 °C. Average annual rainfall of 721.4 mm; most rainy month is October (86.1) and the least rainy months of July (30.4) (Bahadır, 2013) The position of the field under investigation is shown in Fig. 1, with the surface area of 5.5 ha and with 33 monitoring points.

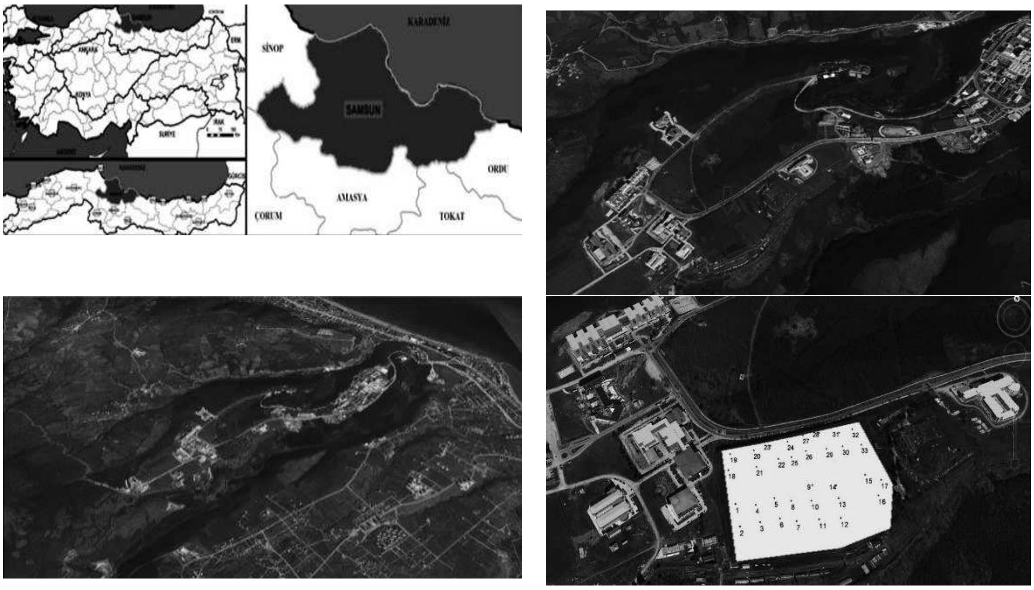

Figure 1. Study area and monitoring points.

Tools and equipment of the study

In this study, GPS, soil auger, test sieves, precision scales, EC and pH meters, pressure vessels and the oven are used for obtaining the necessary data (Fig. 2).

Figure 2. The tools and equipments used in the experiment.

Method

Analysis of Soil samples

With new advances in agriculture and the availability of global positioning satellites, it is now possible to divide a field into smaller units or grid cells that can be sampled individually. Soil test results from each grid can be used to prepare various maps of fields (Thom et al., 2003). pH analysis was performed in soil samples with pH meter. The choice of a proper method to measure pH in soils is a contentious issue (Anon, 2015). In this study pH is measured with pH meter. EC meter values in soil samples were measured with EC meter according to (Rhoadesa, 1990). Field capacity and Permanent wilting point values are mesured pressure plate apparatus, and water holding capacity is found subtracting from each ohter (Günay & Ul, 2001; Temizel & Apan, 2010).

Drawing Maps

Geographic information systems are used in the preparation of the spatial distribution of the data obtained from the field specific point. In order to determine the spatial distribution of the soil properties in the study area were utilized widely used geographic information system . For this purpose map ArcGIS 9.3 software has been chosen for each parameter of ordinary Kriging method (Arslan, 2012; Arslan, 2014).

RESULTS AND DISCUSSION

Soil samples were randomly taken from 33 different location points to depts of 30 cm. Table 1 shows several descriptive statistical parameters belong to general results such as EC, pH, Field capacity (Pw FC), Permanent wilting point (Pw WP), bulk density (γ_t), and Water holding capacity (WHC) of the trial area.

Table 1. Descriptive statistics for studied soil properties

	EC(micromhos cm^{-1})	ph	Pw FC	Pw WP	γ_t	WHC (mm)
Max	1813.00	8.27	0.59	0.39	1.46	61.58
Min	832.00	6.88	0.35	0.20	1.30	52.74
Mean	1278.52	7.56	0.47	0.31	1.38	57.54
Std.dev.	244.981	0.330	0.051	0.039	0.048	2.639
CV	19.2	4.4	10.8	12.4	3.4	4.6

pH Mapping

The pH values ranged between 6.88 and 8.27 (Ave. 7.56). The resulting map of the pH is shown in Fig. 3.

Across the land can be seen from Fig. 3, it is seen that pH values between 7.50 to 7.80. pH values between 7.10 and 6.88 on the map are equal to approximately 0.8% (0.45 da) of all areas of the field. The Area between 7.10 and 7.50 pH values, which is equal to 36.2% (19.90da) of the entire area. Areas having a pH between 7.50 and 7.80 is equal to 57% (31.60 da) of the entire area. Rest area having between 7.80 and 8.27 pH value is equal to 6% (3.44 da) of all areas with pH. It is explicit that every point in map has different pH value.

EC (salinity) Mapping

EC map was plotted by obtaining the data from the field. EC values ranged between 0.832 and 1.813 dS m^{-1} (ave.1.278). EC map shown in Fig. 4 was drawn taking into account the EC data for the study area.

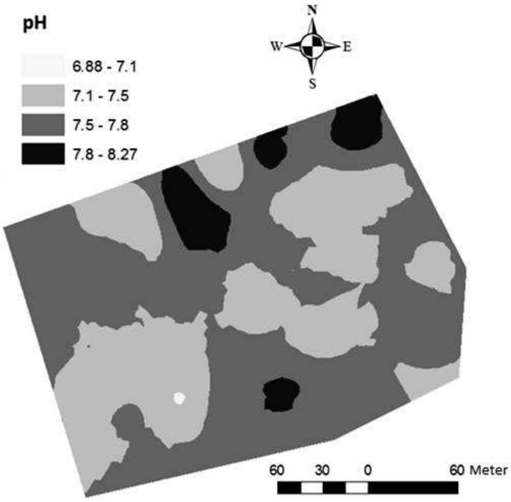

Figure 3. PH maps relating to field.

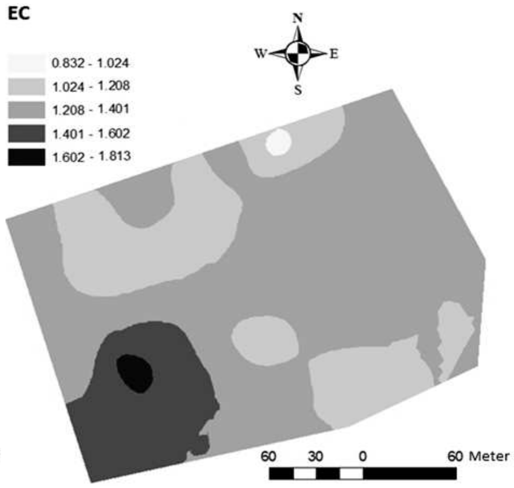

Figure 4. EC map for the area.

As seen in Fig. 4, EC values are shown in four parts. EC values classified between 0.832 and 1.024, 1.024 and 1.208, 1.208 and 1.401, 1.401 and 1.602, and 1.602 and 1.813. Their area ratios are 0.4% (0.23da), 26% (13.74 da), 60% (33.48da), 12.8% (7.09da) and 0.8% (0.45da) respectively.

Soil Bulk Density

Soil bulk density (γ_t) obtained from the soil samples taking the field were plotted shown in Fig. 5.

As seen in Fig. 5, soil density values are ranged 1.30 and 1.46 g cm^{-3}. The area has different soil bulk density. This condition should be taken into account during irrigation.

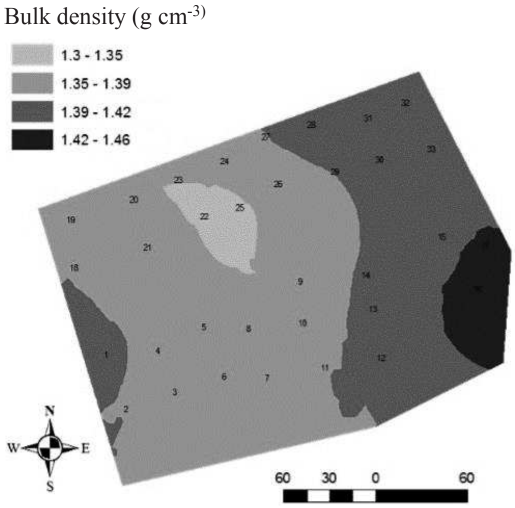

Figure 5. Soil bulk density map.

Field Capacity and Permanent Wilting Point Mapping

The field capacity ranged between 28.12% and 41.56% (Ave. 34.8%) by weight, and the wilting point was in the interval between 16.08% and 25.78% (Ave. 20.9) by weight. The resulting map of the field capacity (FC) and Permanent wilting point are shown in Fig. 6.

As seen in Fig. 6 these values classified in to four group in maps. Their range threshold for FC are 28.12, 32, 35, 37, 41.56 respectively and for the PWP are 16.08, 18, 20, 22, 25.78% by weight respectively. This shows every point in area need different inputs.

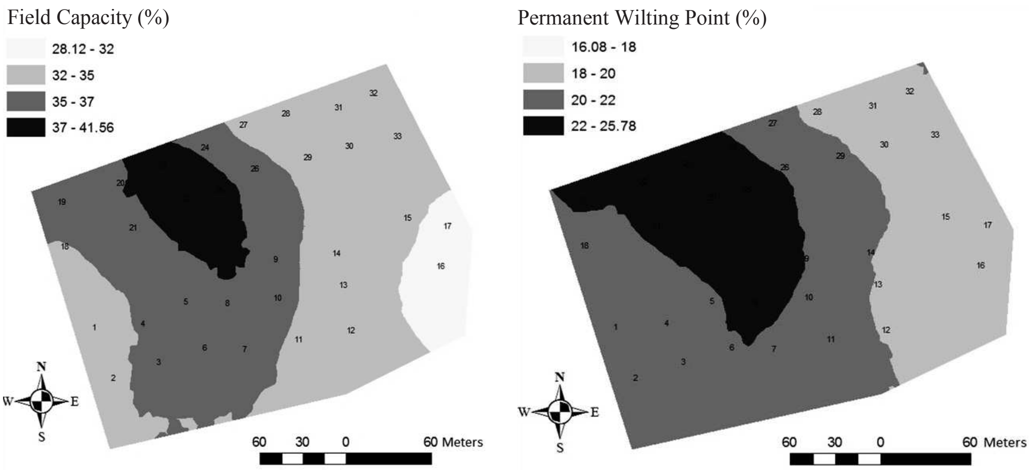

Figure 6. Field capacity (FC) and Permanent wilting point (PWP) maps.

Water Holding Capacity Map

Water holding capacity (WHC) is between field capacity and wilting point. Therefore, water holding capacities are found by subtracting from field capacity to wilting point. Water holding capacities for the field were plotted spatially shown in Fig. 7.

As seen in Fig. 7, Water holding capacities belog to field were classified four group. These groups are between 52–55, 55–57, 57–59, 59–61 mm respectively. It is obvious that most point in area have different value of water holding capacity.

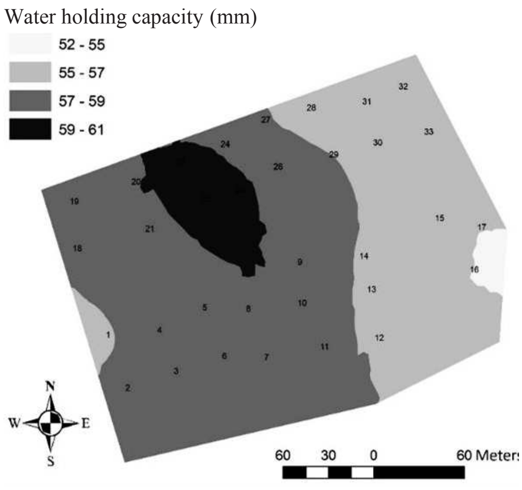

Figure 7. Water holding capacity map.

Drippers flow can be adjusted by on-line emitters for the precision irrigation due to get good distribution uniformity. This condition can be seen in Fig. 8.

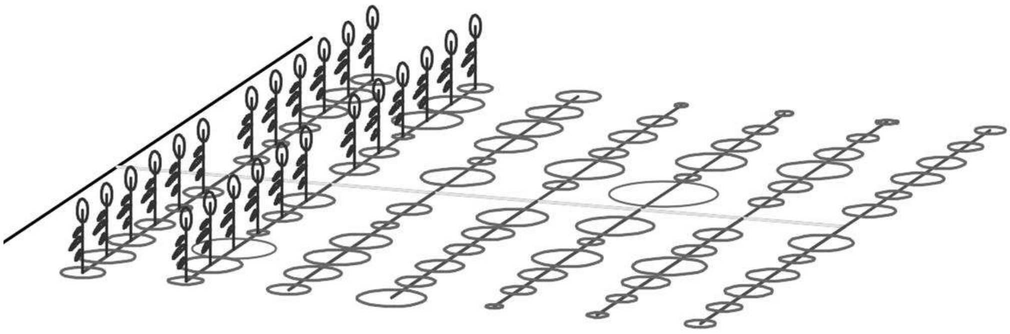

Figure 8. Aspects of different flow of emitters according to water holding capacity.

In drip irrigation Management Allowable Depletion (MAD) can be chosen as about 30% of the water holding capacity (Orta, 2007). When irrigation time is 3.75 h and MAD is 30%, plotted map for the emitter flow (L h^{-1}) shown in Fig. 9.

As seen in Fig. 9, every point in the field have different properties according to irrigation. Therefore, farmers should adjust the dripper flow on emitters respect to the map of precission irrigation.

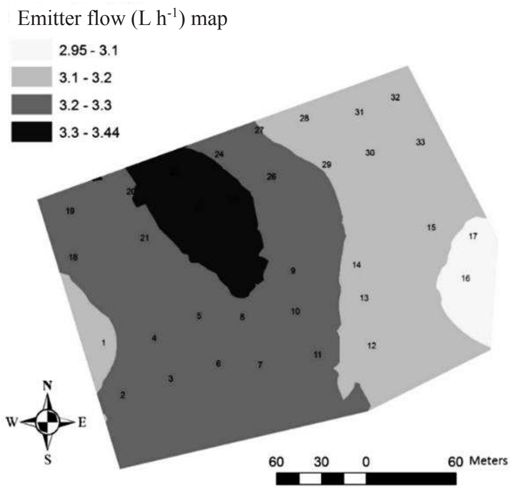

Figure 9. Emitter flow map.

CONCLUSIONS

Precision irrigation used soil parameters for irrigation need some parameters as pH, EC, γ_t, FC, PWP, WHC. One of the aim of precision farming is to send inputs to the points as they need, not too much and not too less. Precision irrigation supply required emitter flow with calculating its value. Conventional irrigation even use drip irrigation, farmers needn't chose emitter flow because of unknowing properties of parameters for irrigation together. While some region of the study area need more water, other side need less water than average. If the farmers use standard flow for the emitters, some region having high water holding capacity gets 18,563 L less water than average. Likewise, some region having low water holding capacity gets 18,563 L more water than its hold.

It means runoff or deep percolation can be seen on the surface resulting erosion. In other words, some region has low water holding capacity, some region has high water holding capacity. If the user irrigate the field according to water holding capacity, user have to decide only one water depth that may higher or lower than mean. This problem can be solve with precision irrigation.

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