Using EC-Based Maps to Manage Soil and Prevent Soil Degradation

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Abstract
Soil conservation and optimal productivity need to more knowledge and awareness from all interfering agents which are involved in using of soil to appropriate plant nutrition, yield increasing and agricultural products quality. At present, excess fertilizer use has been led to increasing soil salinity irrespective to soil solution materials. In order to reduce this effect and fertilizers sustainable management, It is necessary to provide informative maps that show fertilizer distribution pattern. For this purpose, a field sampling was carried out and 52 points were coordinated by GPS. Related measurements of Soil EC were done and the values were interpolated by Inverse Distance Weighted (IDW) and Spline (SP) methods by using digital elevation model and raster spatial analysis procedures. The thresholds of EC to 50% of yield and EC response threshold were used to classify the filed as appropriate and inappropriate zones. This was done for 54 different plants (including cereals, industrial crops, vegetables, trees and shrubs) and appropriate zones for each plant was determined. This can be useful to determine reasonable cropping and rotation patterns to manage EC as a deteriorate factor on soil. More EC can impose soils to degradation during the time and appropriate cropping patterns, especially selection of plants could be useful to alleviate soil erosion and degradation. These reclassified maps could be useful to clarify the ways of optimized use of soil in respect to salinity challenge.
Keywords: Soil salinity, Soil degradation, Sustainable soil management, Soil classification, GIS.

Introduction
Agriculture is being changed by three fundamental forces: the expanding capacity of personal computers, molecular biology revolution, and developments in information technology like geographical information systems (GIS). Through precision farming, all three technologies can be packaged and delivered to producers. The combined impact is likely to lead to the greatest intellectual transition that has ever occurred in agriculture (Clay, 2011). Soil salinization is an agricultural and environmental concern in many arid and semiarid regions of the world. In Iran, salinity affects large areas because of the inherently clayey and saline nature of the soils, intensive irrigation that results in rising water tables, high evapotranspiration, and inadequate drainage. Excessive soil salinity adversely impacts crop production, soil and water quality, and eventually results in soil erosion and land degradation. In these areas, characterizing the spatial and temporal changes in soil salinity is essential to sustain land quality, optimize crop and water management practices, and recommend adequate soil reclamation. Soil salinity as one of the most important reducing factors affecting crops yield and development, is a serious challenge in Iran which 91% arid and semi-arids in total (Kamkar and Mahdavi Damghani, 2008). Therefore, investigation on the soil status is so important to extend agriculture into marginal lands or conserve other lands from salinization and degradation in the future. Precision farming also has concentrated on site-specific managements on small zones to alleviate the reducing effects of this abiotic factor on crop yields. Soil conservation and optimal productivity need to more knowledge and awareness from all interfering agents which are involved in using of soil to appropriate plant nutrition, yield increasing and agricultural products quality. At present, excess fertilizer use has been led to increasing soil salinity irrespective to soil solution materials. Designing cropping patterns for fields also needs informative plans which can be provided by new techniques such as GIS and interpolation methods. Fertilizers can affect soil salinity by affecting pH. In order to reduce this effects and fertilizers sustainable management, It is necessary to provide informative maps that show fertilizer distribution patterns. On the other hand, no planting in vulnerable lands or better management of soils in high-risk areas can help us to improve soil quality and sustain lands exploiting. This study was aimed to provide EC map of a research farm in GUASNR and assess the suitability of detected zones to different plants with different response thresholds to soil EC.

Material and methods

For this purpose, a field sampling was carried out and 51 points were coordinated by GPS. Field border also was determined by tracking using GPS. Related measurements of soil EC were done and the values were interpolated by IDW (ID) and Spline (SP) methods by using digital elevation model and raster spatial analysis procedures (Wollenhaupt et al., 1997, Franzen, 2011). This experiment was conducted in Research farm of Gorgan University of Agricultural Science and Natural Resources, Iran. The EC response threshold was used to classify the filed as appropriate and inappropriate zones. This was done for 54 different plants (including cereals, industrial crops, vegetables, trees and shrubs) and appropriate zones for each plant were determined. For this purpose, the soil samples were collected based on a geo-referenced point located at the transaction points of a grid cell (100m × 25 m) . At each grid point, random cores were collected. Saturation extraction of soil was provided and EC was determined by EC-meter. Field grids and sampling points are presented in Fig.1.

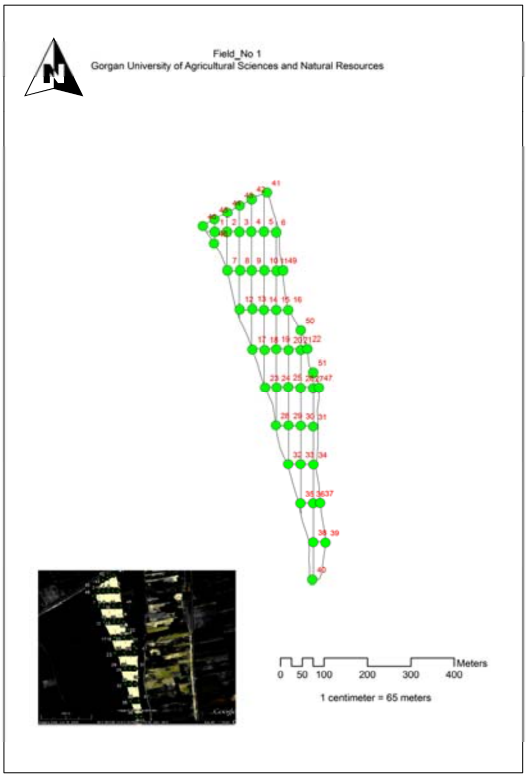

Fig. 1. Field border and sampling points position at the transaction points of grids.

Digital elevation model also was provided by 1/25000 maps and "topo to raster" function with the baselines of contours which were queried from aforementioned maps. Plants which were used in this query have listed in Hall (2001). Raster layers were classified as favorable and unfavorable zones for all 54 studied plants.

Results

Our results indicated that both interpolation methods were appropriate to evaluate EC. Field Ec changed between 0.4-2.48 ds/m and 0.05-2.97 ds/m base on ID and Sp methods, respectively (Fig. 2). Observed against predicted values revealed that SP interpolation method was superior than ID method (RMSE=0.004), but SP method also has reasonable outputs. Therefore, the results of both interpolation methods were provided here. Among 54 plants which were tested here in respect to studied field EC, 49 plants were not faced by EC restriction. 5 plants including (bean, corn, faba bean, turnip and onion) were restricted in many zones which EC value was higher than their threshold. Total field area was 8.502 ha. Our results showed that favorable and unfavorable areas for these plants were not similar (table 1). Therefore, it is advisable that in these zones, cropping of these crops should be avoided, because the yield will reduce by salinity effects, while the soil will be destroyed.

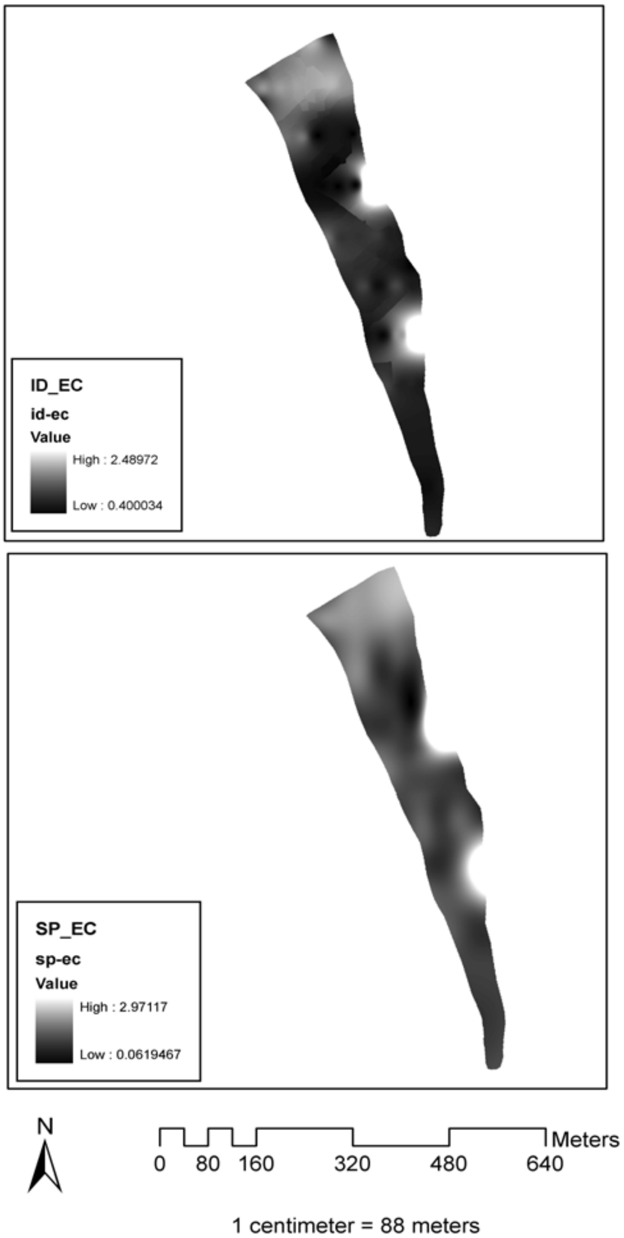

Fig. 2. Ec variability in studied field base on ID and SP interpolationmethods.

Table 1. Plants were used in reclassifying process base on their response threshold and field EC range, total favorable and unfavorable areas and response threshold of plants.

Plants	Favorable (ha)	Unfavorable (ha)	Response threshold (ds/m)
For most of crops	8.429	0.82	2
Faba bean	8.302	0.2	1.6
Bean	8.108	0.4	1
Corn	8.452	0.059	1.7
Onion	8.108	0.40	1.2
Turnip	8.108	0.4	0.9

The map provided for turnip and bean have presented as a sample for both ID and SP interpolation method (Fig. 3 and Fig. 4). The results of other reclassified layers has summarized in Table 1.

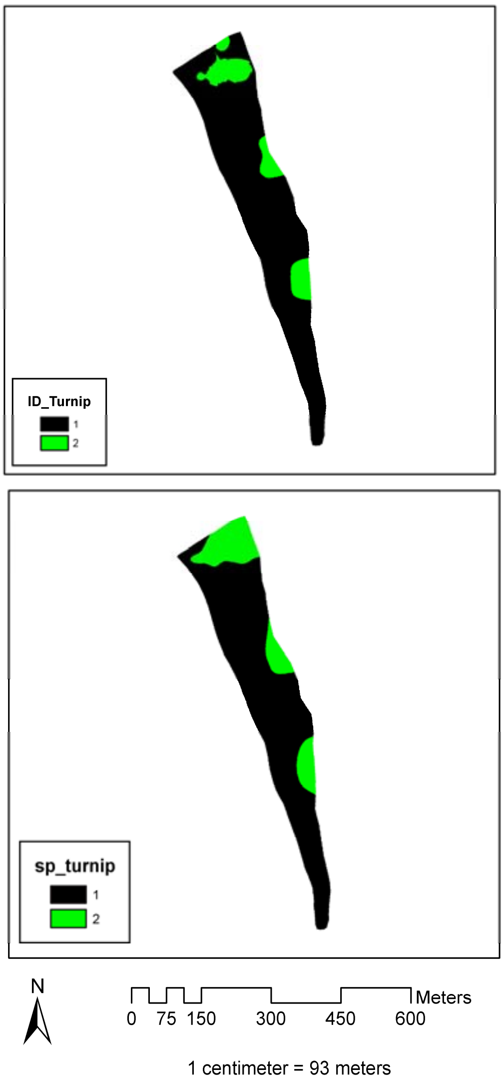

Fig. 3. Favorable (1) and unfavorable (2) areas for turnip cropping in Field #1, Gorgan Univ. Agricultural Science and Natural Resources base on ID and SP methods. For response threshold values refer to table 1.

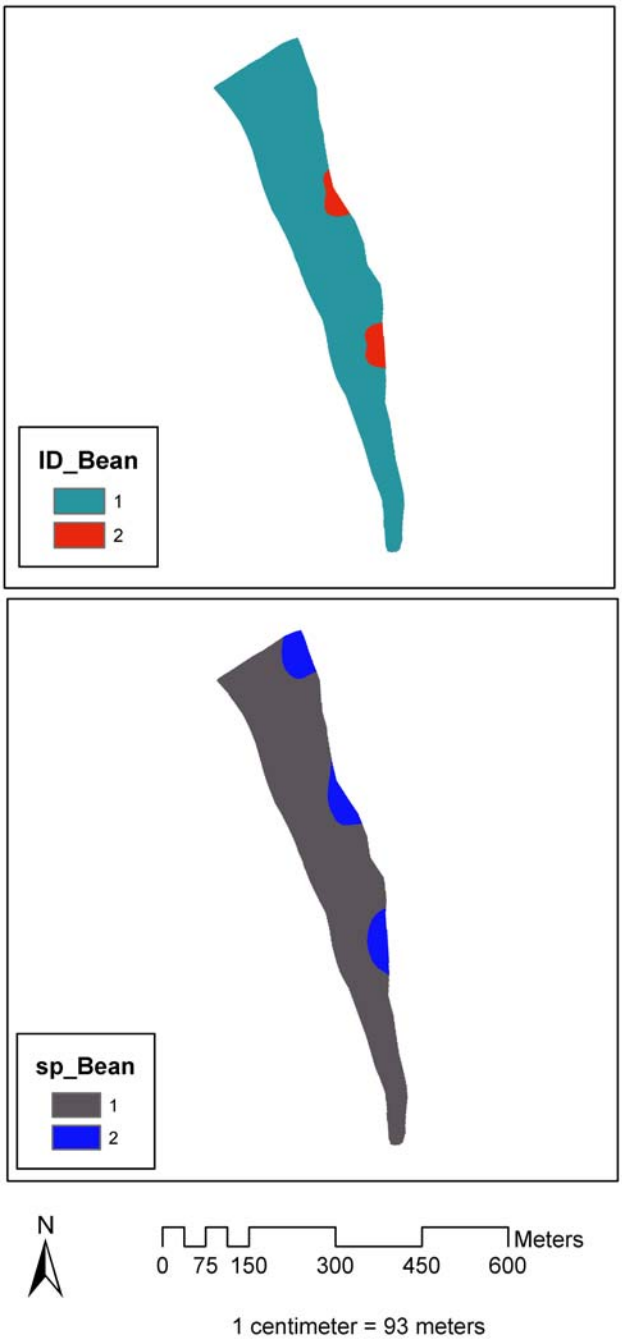

Fig. 4. Favorable (1) and unfavorable (2) areas for bean cropping in Field #1, Gorgan Univ. Agricultural Science and Natural Resources base on ID and SP methods. For response threshold values refer to table 1.

Discussion

Soil degradation is a serious concern which in recent decades has paid much attention on it, because it destroys soil structure and decreases soil quality. Selection of plants that are suitable for a given field is so important to canalize field plans and alleviate negative effects of many other practices such as fertilization or irrigation. Our research revealed that site-specific determination of lands suitability to grow given plants or crops can affect cropping patterns directly and can decrease soil degradation indirectly. Osmotic effects and water uptake interruption are the main effects of soil salinity and consequently yield reduction. Thus, in addition to loss of inputs, and achieving fewer yields, economic reasonability of field will be in question. GIS as a powerful tool can provide applicable maps which can be used as a guideline for growers and policy makers of fields. In this research, different plants showed different plans and this confirmed importance of micro-site detection methods which are the base of precision farming. Thus we can alter crops which are cultivated in these zones or increase irrigation times to dilute salts. Using resistant or tolerant plants also is other option. Spinach family plants are advisable for these areas. These plants are resistant to Na and sodium is an essential element for their growth (sugar beet, spinach, wild spinach). Fertilizers which have chloride, sulfate and nitrate are the main anion compounds which are used in this field. Long-term application of these fertilizers also should be avoided to improve soil situation. It should be noted that these results can be considered in variable rate techniques in respect to irrigation and fertilization aspects.

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