BARD

FINAL REPORT

PROJECT NO. IS-3111-99

Developing Remote Sensing Based-Techniques for the Evaluation of Soil Infiltration Rate and Surface Roughness

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Project Title: Developing remote sensing based-techniques for the evaluation of soil infiltration rate and surface roughness

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Abbreviations commonly: Infiltration rate (IR)

Budget: IS: \$51,500

US: \$48,500

Total: \$100,000

Signature
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Signature
Authorizing Official, Principal Institution

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Publication Summary (numbers)

	Joint IS/US authorship	US Authors only	Israeli Authors only	Total
Refereed (published, in press, accepted) BARD support acknowledged				
Submitted, in review, in preparation				
Invited review papers				
Book chapters				
Books				
Master theses				
Ph.D. theses				
Abstracts				
Not refereed (proceedings, reports, etc.)				

Postdoctoral Training: List the names and social security/identity numbers of all postdocs who received more than 50% of their funding by the grant.

Cooperation Summary (numbers)

	From US to Israel	From Israel to US	Together, elsewhere	Total
Short Visits & Meetings		1		1
Longer Visits (Sabbaticals)				

Description Cooperation:

The cooperation between the two countries was as follows: The Israeli P.I. visited the US P.I. for a period of 10 days during which the methodologies that were developed in Israel, in preliminary studies, were discussed. The US P.I. shipped the US soil to Israel to be studied simultaneously in both countries in order to study the effect of different methodologies on the results. This information is essential for the continuation project that hopefully will be approved. The cooperation among the scientific groups of each country was essential, fruitful and synergistic.

Patent Summary (numbers)

	Israeli inventor only	US inventor only	Joint IS/US inventors	Total
Submitted				
Issued (allowed)				
Licensed				

Abstract

The objective of this one-year project was to show whether a significant correlation can be established between the decreasing infiltration rate of the soil, during simulated rainstorm, and a following increase in the reflectance of the crusting soil. The project was supposed to be conducted under laboratory conditions, using at least three types of soils from each country. The general goal of this work was to develop a method for measuring the soil infiltration rate in-situ, solely from the reflectance readings, using a spectrometer.

Loss of rain and irrigation water from cultivated fields is a matter of great concern, especially in arid, semi-arid regions, e.g. much of Israel and vast area in US, where water is a limiting factor for crop production. A major reason for runoff of rain and overhead irrigation water is the structural crust that is generated over a bare soils surface during rainfall or overhead irrigation events and reduces its infiltration rate (IR), considerably. IR data is essential for predicting the amount of percolating rainwater and runoff. Available information on in situ infiltration rate and crust strength is necessary for the farmers to consider: when it is necessary to cultivate for breaking the soil crust, crust strength and seedlings emergence, precision farming, etc. To date, soil IR is measured in the laboratory and in small-scale field plots, using rainfall simulators. This method is tedious and consumes considerable resources. Therefore, an available, non-destructive-in situ methods for soil IR and soil crusting levels evaluations, are essential for the verification of infiltration and runoff models and the evaluation of the amount of available water in the soil. In this research, soil samples from the US and Israel were subjected to simulated rainstorms of increasing levels of cumulative energies, during which IR (crusting levels) were measured. The soils from the US were studied simultaneously in the US and in Israel in order to compare the effect of the methodology on the results. The soil surface reflectance was remotely measured, using laboratory and portable spectrometers in the VIS-NIR and SWIR spectral region (0.4-2.5 μ m). A correlation coefficient spectra in which the wavelength, consisting of the higher correlation, was selected to hold the highest linear correlation between the spectroscopy and the infiltration rate. There does not appear to be a single wavelength that will be best for all soils. The results with the six soils in both countries indeed showed that there is a significant correlation between the infiltration rate of crusted soils and their reflectance values. Regarding the wavelength with the highest correlation for each soil, it is likely that either a combined analysis with more than one wavelength or several "best" wavelengths will be found that will provide useful data on soil surface condition and infiltration rate. The product of this work will serve as a model for predicting infiltration rate and crusting levels solely from the reflectance readings. Developing the aforementioned methodologies will allow increased utilization of rain and irrigation water, reduced runoff, floods and soil erosion hazards, reduced seedlings emergence problems and increased plants stand and yields.

Achievements

Significant spectral changes resulting from the generation of structural crust were detected on the soil surface of the six studied soils. This finding is innovative and was never studied systematically before. The spectral changes were attributed to both particle size distribution and mineralogical composition effects. Applying varying cumulative rain energy levels to the six soils showed that significant spectral changes emerged, all of which can be characterized and calculated directly from the reflectance curve of the dry soil. These changes were found to be significantly correlated with infiltration values of the crusted soil. The findings of the first-year phase, that fall within the goals we committed to achieve and even further, strongly confirm our hypothesis that crust-related properties are correlated to reflectance spectral information. The result of this research is thus, a solid foundation from which to address all other questions raised in the original proposal as well as others. Based on the above, we intend to further analyze the extensive data sets accumulated during the first year phase in order to study additional possible ways in which crust status can be assessed using reflectance spectroscopy (e.g., specific absorption). Additionally, building a spectral library of crusted soils will be a major task. In this direction, we will study the possibility of creating a general equation for predicting crust solely from reflectance information for large group of soils. Another task will be the examination of current remote-sensing sensors to determine their spectral capabilities to carry crust-related information (band number, position, resolution and signal-to-noise). For that purpose, expanding the area of spectral coverage to cover the VIS region, re-sampling the spectral information to the spectral resolution of common sensors, applying the developed protocol to other environments (rain simulators and spectrometers) and conducting a similar study under field conditions (both under simulated and natural rainstorms conditions). Based on these results we will also consider examining the spectral limit of detection of real remote sensing data. For that purpose, if conditions permit, we will use airborne hyperspectral sensor data acquired over crusted and cultivated fields. By applying a simultaneous field study based on the developed protocols, we anticipate the feasibility to assess the crust status from a far distance.

In general, it can be concluded that in the first-year phase, we achieved all of our declared goals and even more. The results are promising and challenging for the quantitative rapid assessment of soil degradation problems driven by structural crusting processes and funding of the second phase will help us to make this technology more widely applicable.

Available information on in situ infiltration rate and crust strength is necessary for the farmers to consider: when it is necessary to cultivate for breaking the soil crust, crust strength and seedlings emergence, precision farming, etc. Developing the aforementioned methodologies will allow increased utilization of rain and irrigation water, reduced runoff, floods and soil erosion hazards, reduced seedlings emergence problems and increased plants stand and yields.

The cooperation between the two countries was as follows: The US P.I. visited Israel twice; in August 1999 when we planned together the original proposal and in summer 2000 when we discussed the program details. In winter 2001 the Israeli P.I. visited the US P.I. for a period of 10 days during which the methodologies that were developed in Israel, in preliminary studies, were discussed. The US P.I. shipped the US soil to Israel to be studied simultaneously in both countries in order to study the effect of different methodologies on the results. This information is essential for the continuation project that hopefully will be approved. The cooperation among the scientific groups of each country was essential, fruitful and synergistic.

Appendix

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Unpublished data

1) A draft of publication entitled "Systematic investigation of the soil spectroscopy for predicting infiltration rate in typical soils from Israel".

Completion reports

- 1) US
- 2) Israel