The Application Of Micro-Relief Meter For Soil Tillage Studies

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Abstract: Measuring the physical properties of soil provides a good opportunity for careful study of processes such as evaporation from the soil surface, formation of water runoff, sediments and erosion. In this research, the change of some soil hydrological properties was studied in four kinds of primary soil cultivation activities by using a mechanical micro-relief meter. This study was conducted in a randomized complete block design. Data was collected in frames with 9025 cm^2 area and 400 data height were collected for every frame. Measured soil properties were: Root Mean Square (RMS) of height data, superficial Profile Length Ratio (RZ) of soil roughness, Infiltration Recession Factor (RECS), plough depth, the volume of displaced soil, comparison of the area change in relation to superficial evaporation of soil. The RMS of height data was higher ($p<0.05$) with moldboard plow and modified disk plow than chisel and traditional ploughshares. The analysis of height data collected from plots showed that surface evaporation of soil moisture didn't differ by plowing with moldboard plow or traditional ploughshares, compared with two other ploughshares. This statistic was less than the recorded value of developed dish-like ploughshare ($p<0.01$). Also displaced soil mass by these two ploughshares was much more than chisel and traditional ones ($p<0.01$). The developed ploughshare prevents more evaporation. Therefore, plowing surface with this instrument provides high pot-hole store and penetration coefficient compared with other ploughshares. [Journal of American Science. 2010;6(11):85-89]. (ISSN: 1545-1003).

Keywords: RMS of height data, RZ, plough, height data, surface evaporation, pot-hole store

Introduction

The data derived from a micro-relief meter is used in graphic technology and models and geography information system. These data is used to specify channel networks and characterize the location of micro-relief by analysis.

To conserve soil moisture in semiarid areas, superficial evaporation of soil should be prevented. In different of soil cultivation operations, the amount of upper area of plough exposed to evaporation is different so superficial evaporation of soil changes in proportion to the type of soil cultivation. The surface exposed to soil evaporation is obtained by numeral data analysis of roughness. Elliot et al (1997) stated that photometric technology is a good method because of its vast data collection with regard to its collection of more data in every square meter, but it is better to use a brook meter with photometric method. Pini et al (1997) made a laser micro-relief meter which was used by Sevelbent in 2003 to detect spatial distribution plan of sedimentation and micro-morphology. Nicola et al (1999) showed that during heavy rainfall, the physical properties of soil change significantly. They measured change of soil surface roughness by using a laser micro-relief meter. Gazavi et al (1999) compared the operation of moldboard and disk plower. The measured changes consist of the analysis of soils' measure, resistance against penetration, apparent and specific mass, and roughness of the land surface, existing humidity and the amount of mixing materials in soil. They found that developed dish-like ploughshare has better performance in higher speeds. Kamphorest et al (2000) compared the ability of roughness indexes to define maximum pothole store. Five indexes were computed using Digital Elevation Model (DEM) as following: random roughness (RR), tortuosity (T), limiting elevation difference (LD), slope (LS), and Mean Unslop Depression (MUD). Regression analysis on five indexes showed that RR is the best definition about pothole store. Oliver et al (2000) made an automatic micro-relief meter to measure elevation distribution in 5cm network in order to use distribution equation (effusion) of rain erosion. Also, he presented an electronic micro-relief meter with 5cm networked pattern in 2001 and an algorithm to compute the capacity of soil superficial store with millimeter unit in 2002. Michael et al (2003) indicated that using the technique of "acoustic backscatter" shows similar evaluation with roughness statistics of laser micro-relief meter. When roughness degree was sufficiently measured by "acoustic backscatter", the difference between laser micro-relief meter and "acoustic backscatter" technique to compute RMS was less than 9% and for correlation length was less than 13%.

The rainfall modeling, penetration, store and water flowing procedures have been performed by

Brasington and Smart (2003), Betts et al (2003), Darboux and Huange (2005). The geometric definition of soil surface is needed in all models to determine roughness quantity and maximum superficial store.

Carvajal et al (2006) studied the relationship between digital model of ups and downs and estimation accuracy of maximum pothole store. They achieved a prediction model to estimate the error of maximum pothole store. In their study, usable data were roughness of soil surface and analysis of digital model. Arvidsson et al (2006) computed ups and downs of soil surface using a micro-relief meter with 0.64m area to study moisture effects of soil during plough and showed that in moldboard plowing in low soil moisture conditions, soil softness is more than plowing with chisel. The change in soil surface elevation has been performed in primary soil cultivation by measurement. Their study investigated individually the effect of several kinds of soil cultivation on soil physical properties. Mechanical micro-relief meter was used to remove roughness data of the surface. Measured properties were RMS of height data, superficial RZ of soil roughness, RECS, plough depth, the volume of displaced soil, comparison the rate of soil porosity and area change in relation to surface evaporation of soil.

Material and Methods

Measurements were performed in Khatoonabad research farm of Azad Islamic University, Khorasgan branch, in July 2007. Khorasgan is located in east of Esfahan and with 51' 46" longitude and 32' 38" latitude. The farm soil has heavy clay texture and the wheat residues of previous season were in farm. The study was done according to randomized complete blocks. Four kinds of soil tillage machines moldboard plow, including converter, used chisel plow, traditional plow and modified disk plow (Yule and Roddy 1994; Ghazavi 1997) were used on three adjacent blocks. The width and length of every plot were 3 and 25 meters, respectively and slope of all plots was (0.004) and vertical on them (0.002). After soil plowing on plots, height data was measured by mechanical micro-relief meter. Micro-relief meter consisted of one row of pins which could be used to measure one row of height data on graded sheet by contacting the tip of pins ground. The height data could be read by the position of pin top tip from the graded sheet. Finally one plot with 9025 cm^2 area and 5cm networking were measured, and 400 height data were obtained for every set of micro-relief meter. Micro-relief meter provide data by which the surface of different lands after plough with different tillage machines can be compared. The erosion is studied by the data of surface roughness before and after rainfall in different times. Furthermore, soil pothole store can be measured and according to rainfall statistics, land's roughness can be modified by soil tillage machines to prevent water flowing. This provides a good practical method for preventing erosion in both agricultural and grasslands.

The measured data was rendered as matrixes with coordinates (x , y , z) and in the form of digital elevation model (DEM) data. Then data of numeral model was transferred to the computer and its relevant micro-topography with drawn by SURFER (V.8) software, then parameters of these micro-topography were computed. The statistical analysis of data was done by SAS (v.8) software. Two factors were used to determine roughness indexes with RMS and superficial RZ. RMS is height numeral data and superficial RZ is obtained as following:

RZ = the upper area of frame unit / the area of frame unit

The more area of roughness is the more soil surface in direct contact with air increases. So evaporation increases that this matter is effective in wasting of water in arid and semiarid areas. Therefore, the surface exposed to evaporation was computed in different tillage's and then compared with each other. Also, positive micro-topographic volume was computed in high level of plough depth and called soil displacement volume for every plow. EUROSEM (The European Soil Erosion Model) has been designed to simulate the erosion of water and sediment by using grooving procedures. In this model, application scale is farms and small areas. EUROSEM uses two parameters to determine soil roughness. These parameters are RFR (roughness measure) and RECS. RECS is the mean of elevation difference between highest and lowest of width section of soil. This study uses RECS to specify the tool of soil cultivation. Micro-relief meter was used to determine RECS.

Results and Discussion

Figure 1 shows the micro-topographies of some plots. The results of variance analysis have been shown as tables. According to these tables, RMS of plowed soil with moldboard plow is more than RMS of chisel and traditional ($p<0.05$). RMS of modified disk plow did not have differ with moldboard plow. In result, these two machines have the most roughness and pot-hole store. Superficial RZ of plots showed the same RMS order of height data. Also, the area exposed to evaporation and superficial RZ show meaningful difference in 1% statistical probability level. The analysis of removed height data showed that superficial evaporation of soil moisture does not indicate significant difference between moldboard plow and composite plows (the evaporation in modified disk plow is less than moldboard plow because of plant remains on land surface, while for two others is less ($p<0.01$) than modified disk plow). Table 5 shows the values of RECS measured for tools. The coefficient of variation for measurements of elevations RMS is 12.7%. Where RZ and S had values 4.9% and 3%, respectively, showing appropriate accuracy of measurements.

Table (1): Analysis of variance for root mean square of elevation data

Source	DF	Adj MS	F
R	2	0.3756	2.43^{ns}
T	3	1.4248	9.21*
Error	6	0.1574	

ns, non significant ($p>0.05$)
* and **, significant at 0.05 ($p<0.05$) and 0.01 ($p<0.01$)

Table (2): Analysis of variance for RZ

Source	DF	Adj MS	F
R	2	0.00142	1.12^{ns}
T	3	0.019810	15.69**
Error	6	0.001263	

ns, non significant ($p>0.05$)
* and **, significant at 0.05 ($p<0.05$) and 0.01 ($p<0.01$)
RZ, superficial Profile Length Ratio of soil roughness

Table (3): Analysis of variance for S

Source	DF	Adj MS	F
R	2	115756	1.13^{ns}
T	3	1614195	15.71**
Error	6	102749	

ns, non significant ($p>0.05$)
* and **, significant at 0.05 ($p<0.05$) and 0.01 ($p<0.01$)
S, area change in relation to superficial evaporation of soil

Table (4): Mean analysis

Tillage type	RMS	RZ	S (cm^2)	V (cm^3)
Moldboard plow	3.969(a)	1.286(a)	11607(a)	105327
Modified disk plow	3.404(ab)	1.284(ab)	11320(ab)	107723
Chisel	2.831(bc)	1.168(bc)	10538(bc)	71752
Traditional plough	2.282(c)	1.108(c)	10000(c)	50368

RMS, root mean square of elevation data
RZ, superficial Profile Length Ratio of soil roughness
S, area change in relation to superficial evaporation of soil
V, volume of displaced soil

Table (5): RECS measures for tillage machines

	Moldboard plow	modified disk plow	Chisel	Traditional plough
RECS	17.33	15.42	10.21	8.35

RECS, infiltration recession factor

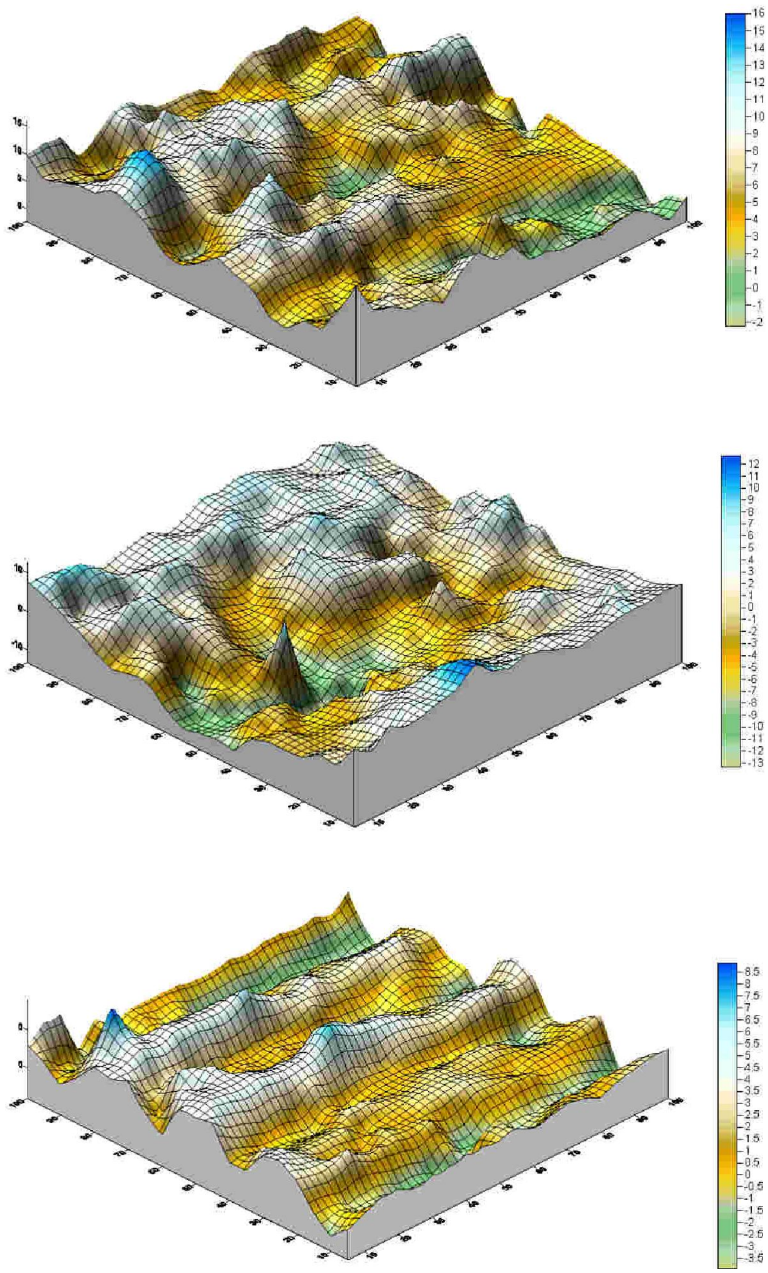

Figure (1): The micro-topographies of some plow.

Conclusion

Displaced soil by modified disk and moldboard plows was much more than chisel and traditional plows. Because of high soil displacement and pothole store, the modified disk plow displaces soil with an angle less than moldboard plow. It can preserve soil moisture and prevents water evaporation. Therefore, plowed soil surface with this machine had high pot-hole store and penetration coefficient, reduces water run off, Prevents soil surface crusting and soil erosion in comparison with moldboard plows. In addition it would be possible to work at higher speed by using a more powerful tractor. Although, the moldboard plow is a standard tillage tool. The new one with above mentioned benefits can be used as an alternative machine for tillage operations and rainwater storage system.

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