THE EFFECT OF SURFACE ROUGHNESS ON THE SOIL LOSS

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ABSTRACT

Field measurements and lab analysis were conducted to determine the effect of soil surface roughness (oriented and random) resulted from discing and chiseling on the soil loss by wind erosion. Some soil ridges parameters were measured in the field and aggregation (clods and non-erodible aggregates) were determined in the lab. The soil loss of the two operations was determined as a function of these variables. The results showed that the large proportions of random roughness(large clods) and clear oriented roughness (soil ridges) in the tilled layer after soil discing have a greatest effect in reducing the amount of soil loss and potential erosivity of soil by wind action in comparison with soil chiseling .This is attributed to the fact that the soil clods easily crushed into fine aggregates after soil chiseling but remained unchanged in soil discing .The statistical analysis coming in agreement with the results of the lab and field investigation

INTRODUCTION

The objective of primary and secondary tillage for wind erosion control is to produce rough and cloddy surfaces which have a greatest effect in reducing erosion by sheltering and trapping the blown soil particles and decreasing the wind velocity near the rough surface (Hofman and Franzen, 1997). In other word, for any given soil conditions the amount of soil which will be blown depends on the two factors; the prevailing wind velocity and the roughness of soil surface (Romken *et. al.* 2001). An empirical-logarithmic formula suggested by Kirkby and Morgan(1987) for the relationships showed that;

$$Z = 0.81 (Log \ 5.5 \ ds) \ .... (1)$$

Z = The height above erodynamic surface at which the wind velocity =zero
ds = Grain or aggregate diameter (mm)

The value of Z was varied with the logarithemic of grain or aggregate diameter, therefore the Z value over rough surface was greater than that of smooth surface. For this reason the height of soil surface during the measuring processes should be corrected due to changes in height of reading it made(Gomez ,2005). Many researchers have reported that the disc and chisel are the most common tools used to roughen the soil and bring clods to surface for wind erosion control and reducing soil loss (Saleh, 1997, Hofman and Franzen, 1997) , but other workers mentioned that tillage in general can gradually reduces the soil surface roughness by breaking the clods and aggregates that resist wind erosion(USDA,2008). Surface roughness is very important factor when measured the total soil loss from a given field. Woodruf and Siddaway (1965) have developed an empirical equation for estimation the erodibility of soils. The wind erosion equation (WEE) developed by these workers estimate a potential erosion in ton/acre as a function of five independent variables.This equation is ;

A= f (I , K , C ,L V)..(2)

A = Soil loss t/acre   I = Soil erodibility factor
K = Soil roughness factor   C = Climatic factor
L = Unshelterd length factor   V = Vegetation cover factor
f = function

Among the factors which help to protect soil from wind erosion , soil roughness factor(K-factor). Garcia *et. al.* (2008) have reported that K-factor estimates the fractional reduction of erosion caused by ridges and non-erodible aggregates. Therefore K has been divided into; soil ridge roughnesss sub-factor (Krd) and soil random roughness sub-factor (Krr),then;

$$K = Krd + Krr ....(3)$$

The objective of the study reported here ,was to provide an important informations on the interaction effect of random roughness (aggregation) and oriented roughenss (soil ridges) resulted from soil discing and chiseling (which are widely used operations in agricultural dryland farms at northern Iraq) on the soil loss by wind action, and to compare the profitibility of the two operations under this condition in order to indicate areas where further researches are needed.

MATERIALS AND METHODS

The study was conducted on the selected farm located at Kaber Al- Abid area (about 20 Km south Mosul city). Table (1) showing some physical, chemical characteristics and classification of studied farm's soil. Composite surface soil samples (0-25 cm in depth) was taken from tilled layer after discing and chiseling .This depth selected because many field observations indicated marked soil structural differences occurred approximately within this depth.

Table(1): Selected characteristics of studied farm's soil

Clay	Silt	Sand	Texture	pH	EC	OM	CaCO3	Classification
gm / kg					dS/m	gm / kg		
372	367	261	Silty Clay	7.7	0 .44	9.8	288	Entisol

The soil samples were air- dried and gently crushed to pass through a 4 sieves. Dry sieving for four fractions (2, 1, 0.50, and 0.25 mm) were done according to the procedure mentioned by Kemper and Rosenau (1986). Samples were sieved two times. The accumulated percentage of soil aggregates passing through each sieve was substitute in the following equation to calculate the Arithmetic Mean Size (AMS) for each soil treatment as reported by Emond (1971);

$$AMS = \frac{1400 - (Y1 + 3/2 Y2 + 3Y4 + 8Y8)}{400} - ....(4).$$

Where;
   Y1= soil aggregates passing through 0.25mm sieve.
   Y2, Y4 and Y8 = the accumulated percentage of aggregates passing through
                    0.50 , 1.0, and 2.0 mm sieves respectively
       The standard dry sieving procedure repeated by resieving the non -
erodible aggregates (NEA) expressed as percent larger than 0.84 mm in
diameter .The obtaining values were plotted on the table (2) to obtaining the
soil erodibility factor(I) of wind erosion equation (WEE).

Table (2): Soil erodibility factor(I) in Mg / ha. as a function of % NEA.

Percent	Unit									
	0	1	2	3	4	5	6	7	8	9
0	-	694	560	493	437	403	378	356	335	315
10	300	292	285	278	270	262	254	245	236	228
20	220	213	206	200	195	190	185	180	175	170
30	166	162	158	154	150	146	142	138	134	130
40	126	122	118	114	111	108	104	99	94	89
50	84	79	74	69	65	61	57	54	52	49
60	47	45	43	41	39	37	35	33	31	29
70	27	25	22	19	16	13	10	7	6	5
80	4	-	-	-	-	-	-	-	-	-

       In addition, the study was extended to measure directly in the field the
following parameters of soil surface roughness; the maximum peak height
(MPH), maximum depression depth (MDD), peak roughness frequency (PRF),
and peak roughness frequency to peak roughness height ratio (PRF/PRH) and
tortuosity (TOR) which is the ratio between actual peak roughness height and
project (on the horizontal plane) of profile of the soil surface(Saleh, 1997).
Peak roughness heights (PRH) were measured ten-times in various farm
directions using measuring ruler to obtain the mean peak ridge height which
plotted on non-linear measure curve of roughness (fig 1) to obtaining the
equivalent soil roughness factor (K). The curve was based on a design wind
velocity of 50 mile/hr at 50 ft height with wind direction at 45 degree to
field(Woodruf and Siddoway 1965,Lehrsch $et. al$. 1988.).
              E = f (I   *   K   ) .... (5)
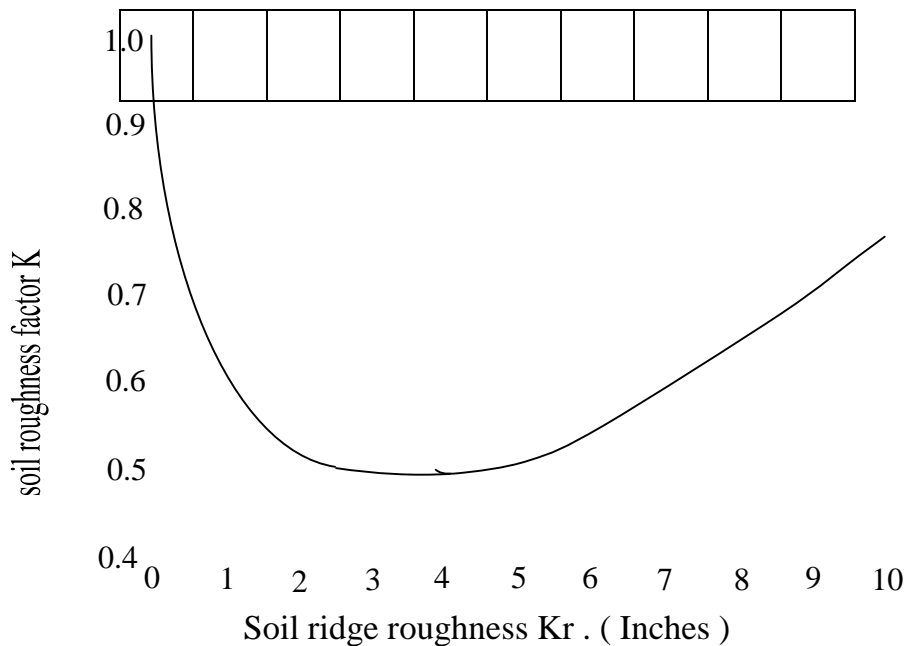
Fig.1.Soil roughness factor K as a function of soil ridge factor Krd

The K factor in the wind erosion equation (WEE) is a soil roughness factor which dose not include the random roughness. The potential average annual soil loss by wind (E) was calculated as a function of soil erodibility factor (I) and soil roughness factor (K) therefore; The comparison between the two operations (discing and chiseling) was done statistically by obtaining the Coefficient of Creation (CC) for each tool using the following logarithmic equation (Steel and Torri ,1980) ;

$$CC = \frac{Log\ Y1 - Log\ Y2}{Log\ X1 - Log\ X2} \qquad \text{--- - - - -------------} \qquad 5$$

Where;

   Y1 and Y2 = the higher and lower measured values of the K factor after soil tilled.

   X1 and X2 = the higher and lower measured values of the K factor before soil tilled .

The relations between potential soil loss (E) - soil erodibility factor (I) and potential soil loss (E) - soil erodibility factor(I) * soil roughness factor (K) for each tool were analyzed statistically using the regression analysis. All statistical analysis were run on SAS software.

RESULTS AND DISCUSSION

   The following discussion of soil surface roughness (SSR) include the interaction of random roughness (aggregation) and oriented roughness (soil ridges) on the soil loss. Aggregate size distribution (random roughness) of studied soil field (as shown in table 3) indicated that the soil chiseling was more effected and resulted in fewer aggregates than discing. The soil chiseling operation resulted of 28.54 % in 0.50- 0.25 mm size range and more 27.16 % in discing up to 2.0 mm in size.

Table. (3): % Aggregate size distribution (< 2) after discing and chiseling .

Treatments	2 -1mm	1 – 0.5mm	0.50 - 0.25mm	<0.25mm	AMS(mm)
Discing	27.16	24.40	33.68	14.62	0.74
Chiseling	20.82	22.28	28.56	26.54	0.61

This variation may be attributed to the fact that the aggregates easily crushed by soil chiseling into fine aggregates of less than 0.50 mm in comparison with soil discing, which aggregates remained, unchanged. This result led us that the AMS of soil chiseling was less than that of soil discing .The AMS were 0.74 mm and 0.61 mm for discing and chiseling treatments respectively. From the physical view, this variation was not significant because the AMS values of the both operations are identical with that of sand particles. The soil aggregates (random roughness) of more than 2mm in diameter in the 1st sieving for both operations were reduced in the 2nd sieving. (Table 4).This mean that the continuous soil discing and chiseling will minimize the size range of soil aggregates to the limit which easily eroded by wind. For this reason the expected AMS value in the 2nd sieving will be less than that of 1st sieving for both operations

Table(4):Sand-size aggregate distribution % after for 1st and 2nd sieving produced by the two operations

Treatments	1st sieving		2nd sieving	
	>2mm	< 2mm	>2mm	< 2mm
Discing	51.60	48.40	40.95	59.17
Chiseling	45.10	73.09	19.74	80.26

On the other hand , the soil surface roughness (SSR) increases as the proportion of NEA in the tilled layer increases. The proportion of NEA after discing and chiseling are 46.15% and 33.85% respectively. The more NEA % resulted from soil discing, the greater will be the volume of the non- erodible projection at the surface of the soil and the less the amount of soil loss that will occur, in comparison with soil chiseling. Other parameters described oriented roughness (as present in table 5) showed that the resulted roughness from soil discing has a high values in comparison of soil chiseling. This variation attributed to the primary effects of random roughness which also raised the tortuosity of tilled soil layer and made slight differences between the two operations.

Table(5):Selected roughness parameters of soil discing and chiseling operations

Treatment	NEA%	MPH	MDD	PRH	PRF	PF/PH	TOR
		Cm					
Discing	46.15	18.1	9.10	20.4	4	1/2.6	0.71
Chiseling	33.85	12.1	6.66	15.9	5	1/2.5	0.66

In order to determine the total effectiveness of K-factor (Krd + Krr), the NRCS(2002) ,has reported that the Krr sub-factor for random roughness value

which has been used to estimate the soil loss by WEE will be determined from table (6) .The Krr sub –factor for random roughness has been devloped for various level of soil erodibility index(I)values (table 6).The extracted values of Krr has been added to Krd (which is obtained from fig.1) to account the soil roughness factor(K)..

Table(6):Krr values for Peak roughness height (PRH) and I-factor(NRCS 2002)

Ridge height(Cm)	I = 104	I = 86	I < 56
5	1.00	1.00	1.00
10	0.95	0.86	0.70
15	0.88	0.76	0.51
20	0.82	0.68	0.40
25	0.78	0.62	0.34
30	0.74	0.57	0.30
35	0.72	0.54	0.27
40	0.69	0.51	0.24

From this table , emergency tillage can be done on soils have been an I-factor >104 Mg/ha (Garcia *et al* 2008). For this reason the ridge height (oriented roughness) at right of prevailing wind direction and with space rate of 1:4 resulted from soil discing (20.4cm) is more than that of soil chiseling (15.9cm). This variation in ridge height reflect the mechanism of each tool in producing a rough surface .

The potential soil loss(E) by wind in both operations are calculated and presented in table(7). When soil erodibility factor (I) is 104 , 154 Mg / ha and roughness height are 20.4 , 15.1cm , the Krr values (as shown in table 6) are 0.82 and 0.88 for soil discing and chiseling respectively. Therefore ,the potential erosivity(E) of soil by wind action { E = f [I * (Krd + Krr)]} was 14.27 Mg/ha for soil discing and was 22.79 Mg/ha for chiseling (table 7).

Table(7): Soil loss E as a function of I and K (Krd+Krr) of the both operations

Treatment	I	Krd	Krr	K	E = I * K
Discing	104	0.55	0.88	0.143	104*0.143=14.27
Chiseling	154	0.65	0.82	0.148	154*0.148=22.79

This results coming in agreement with the results of statistical analysis. Linear regression were run on the potential soil loss(E) – soil erodibility(I) * soil roughness (K) . The best fitting regression equations are listed in table (8). The high values of both coefficient of determination (R^2)and coefficient of creation (CC) indicated that the two operations were highly correlated and the variations in R^2 and CC values between the two operations were small. These results can be obtained from the fact concluded before, that the surface aggregation (random roughness) with high AMS and high elevation of soil ridges (oriented roughness) and tortuosity resulted a rough surface and less amount of soil loss.

Table (8): regression equations predicting soil loss (E) = f (I * K)

Treatment	regression equations	R2	CC
Soil discing	Ed = 7.54 + 0.061 (I) + 5.41 (K)	0.91	1.71
Soil chiseling	Ec = 10.11 + 0.074 (I) + 8.10 (K)	0.97	1.55

At the end we can concluded that the comparison of results obtained in the present study showed that soil surface roughness (SSR) is related to the single aggregation size classes and the most soil particles under these conditions spacialy the particles > 2 mm in diameter breakdown into fine particles which are easily eroded (lost) from field by wind action. Thus, temporal variability of soil surface roughness including aggregation and non-erodible soil fractions(> 0.84mm in diameter) may be considered in soil researches in agricultural soils .Also frequent measures are needed and the resulting soil surface roughness (SSR) is short lived, because ridges can be filled and the roughens broken down by abrasion to produce a smooth surface susceptible to wind.

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تأثير خشونة السطح على معدل فقد التربة

خالد فالح حسن

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الخلاصة

أجريت قياسات حقلية وتحليلات مختبريه لبيان تاثيرخشونه السطح الناتجة من الحراثة الأولية بالتي الدسك والجيزل على معدل فقد التربة حيث أجريت قياسات حقلية لارتفاعات الكتوف وتحليلات مختبريه لتجمعات التربة ومجاميع التربة غير القابلة للتعرية.

أشارت النتائج إلى إن الكتوف ومجاميع التربة غير القابلة للتعرية لهما دور كبير في تقليل معدل الفقد الحاصل من سطح التربة وكان معدل الفقد الحاصل بعد الحراثة بالدسك اقل بالمقارنة بالفقد الحاصل بالة الجيزل وجاءت نتائج التحليل الإحصائي متمشية مع نتائج التحليلات المختبرية والحقلية .

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