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EFFECT OF TILLAGE PRACTICES ON SOIL EROSION BY WIND UNDER CONDITIONS OF NEW RECLAIMED AREAS

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ABSTRACT: The evaluation of the quantity of soil loss by wind erosion due to tillage practices was studied through Oct-2002 to Oct-2003 in both West Nubaria and Maryut Research Station (Desert Research Center) using three tillage machines (chisel plow, rotary cultivator and combination unit) and three different forward speeds were used for every machine. The field experiments were carried out in two sites have different soil types. The obtained data showed that the use of combination unit was followed with highest values in soil erodibility, soil loss, fuel energy requirements as well as crop yield, while the chisel plow represent the most highest values for crop residue cover, however it achieved the lowest values in fuel energy requirements, yield and soil loss. The contribution of tillage erosion in the total amount of soil loss due to wind erosion was illustrated.

Key words: ***tillage, wind erosion, soil texture, energy, yield.***

INTRODUCTION

Wind erosion is a serious problem in many parts of the world. It is worse in arid and semi-arid regions. The exaggerated mechanized tillage resulting from the use of powerful heavy machines lead to destroy soil structure and its stability, so the soil becomes more vulnerable to wind erosion. Papendick, 2003 described erosion by wind of special concern with dry farming if there are: 1) low crop residue produced, 2) coarse-textured soils low in organic matter and 3) traditional tillage which reduce soil roughness and bury much of the crop residue. Zobeck and Popham, 2001 studied the roughness indexes related to the wind erosion due to tillage. They measured roughness using for three seasons on fallow, cotton and sorghum on west Texas. In general, the roughness indexes fell into three broad tillage groups. The ridging tools (rolling cultivator and lister) produced the greatest roughness. The chisel, knife sweep and cultivator produced the least roughness and the remaining tillage tools comprised an intermediate group. Shrinivasa *et al.*, 2001 reported that conservation tillage represent new techniques to reduce soil erosion, in the same time it conserve moisture , soil structure, reduce energy inputs and production costs, improve land use and reduce labor costs. It also attempts to reduce primary soil tillage operations such as plowing, ripping, disking and chiseling, and dedicates tractor traffic to zones away from growing crops, as a result of reduction in tractor operations, more over growers may save energy, produce less dust and sequester more carbon into the soil.

MATERIALS AND METHODS

The field experiments were carried out in two sites, West Nubaria area, site (1) (The International Company for Land Reclamation) 90 km of Alexandria-Cairo desert road, and site (2) at Maryut Research Station (Desert Research Center) 37 km of Alexandria-Cairo desert road. The soil properties of each site was given in Tab.. 1. The experiments in two sites were conducted during winter and summer seasons (2002-2003 and 2003) to study the effect of tillage machine types and their forward speeds on soil loss by wind erosion, crop yield and some soil properties related to soil erosion as well as fuel energy requirements.

Such soil properties were determined according to Black *et al.*, 1965. However soil erodibility was determined according to Woodruff and Siddoway, 1965. Different crops were cultivated through the period from 2002-2003. The experimental area was about 6.5, 3.25 feddans for West Nubaria and Maryut site, respectively. Concerning West Nubaria site the experimental area divided into 9 equal plots (60x35m), every three plots were occupied by chisel plow using different speeds for every plot (3.1, 4.8 and 5.02 km/h).The same procedure was applied with rotary cultivator and combination unit, all tillage treatments were carried out at tillage depth of about 15 cm. Concerning Maryut site the same treatments were applied except the area of the plot was 35x30 m. A mechanical planting (planter for potato and corn silage, and seeder for barely) was used for all treatments. The machine specifications were as following:

1-Chisel plow: mounted type have blades of 7 , double point shares with working width of 175 cm.

2-Rotary Cultivator Model Emagro (Italy) with working width of 185 cm and Number of blades 36 with L shape.

3-Combination unit: Model DUZI 2.F.(Germany), mounted type and controlled hydraulically with working width of 160 cm and have 3 tines.

The treatments were as followed:

A) Chisel plow at (3.1 km/h) + Mechanical Planting.

B) Chisel plow at (4.8 km/h) + Mechanical Planting.

C) Chisel plow at (5.02 km/h) + Mechanical Planting.

D) Rotary cultivator at (3.1 km/h) + Mechanical planting.

E) Rotary cultivator at (4.8 km/h) + Mechanical planting.

F) Rotary cultivator at (5.02 km/h) + Mechanical planting.

G) Combination unit at (3.1 km/h) + Mechanical planting.

H) Combination unit at (4.8 km/h) + Mechanical planting.

I) Combination unit at (5.02 km/h) + Mechanical planting.

The experimental parameters measured were as followed:

Soil erodibility :

The percentage of dry stable aggregates >0.84 mm was determind as an indicator of soil erodibility before and after tillage practices for every season as described by Zobeck and Popham, 2001.

Soil loss:

Samples of eroded soil material were collected using 2 types of traps, which were put in the field, the eroded materials were collected for each crop season and after every tillage practice to measure the soil loss. The traps were: Big Spring Number Eight (BSNE), which collect soil loss samples through an opening 50 mm high and 20 mm wide at 30,50 and 100 cm above the soil surface as described by Fryrear, 1986. While the other trap is consisted of a tray of 30x30x5 cm fixed on the ground surface and collect the soil drift which is resulted from the tillage practices.

Soil ridge roughness factor:

The soil roughness of ridges produced by tillage and planting equipments is expressed by a roughness factor (R) calculated from the following equation .

$$R = 4\,H^2 / I$$

Where

R= soil roughness factor.
H= the ridge height (mm).
I= the distance between the ridges (mm).
This method was descriebed by Morgan, 1995.

Plant residue cover:

The plant residue cover was measured by placing a square wire gird, 25 X 25 cm, having 100 intersections over the soil surface. Each intersection touch a plant was counted as 1% soil cover as described by Bilbro, 1989 before and after every tillage practices.

Fuel energy requirements (Ef):

This energy includes the power used and the efficiency of the fueland can be found as the following according to Lower *et al.*, 1977.

$$Ef = \frac{CF}{FC} P.FE$$

Where:

$$FE = 2.64X + 3.91 - 0.2\sqrt{788X + 173}$$

Ef:energy used as fuel.MJ/fed
CF:energy coefficient used to represent the energy value of the fuel = 47.2 MJ/L.
P = Power used kW
FE = Fuel efficiency L/kW.h
X = Load factor = 0.2-0.8 for transportation and agricultural operations.
FC : field capacity. fed/h

Crop yield:

The cultivated crops through the seasons in Nubaria site were Potato through the winter season (2002- 2003) and corn silage through the summer season (2003), while the cultivated crops in Maryut station site were barley through the winter season (2002-2003) and Sorgum through the summer season (2003). The crop yields were determined after harvesting and calculated in (kg/fed) for all cultivated crops.

Each crop was statistically analyzed to evaluate the significancy of the treatments under consideration.

Table1: Particle size distribution of the soil.

Location	Depth (cm)	Particle size distribution (%)				Texture class	Soil Aggr. >0.84 mm(%)	pH soil past	Ece dSm-1	Total CaCO3 (%)
		Coarse Sand	Fine Sand	Silt	Clay					
West	0-30	40.75	40.65	2.5	16.1	Sandy Loam	42.7	8.37	1.62	4.24
Nubaria	30-60	33.19	33.37	27.1	6.32	Sandy Loam		8.64	0.84	4.59
Maryut	0-30	19.82	28.34	20	31.9	Sandy Clay Loam	25.7	8.45	2.8	40.02
Station	30-60	32.58	12.12	17.4	37.9	Sandy Clay		8.51	1.32	43.89

RESULTS AND DISCUSSIONS

The discussion will cover the results obtained under the following headings:

1.Soil erodibility:

Fig. 1 shows the results of mean dry percentage of soil aggregates > 0.84 mm before and after tillage treatments for the cultivated crops. It is clear that the value before tillage was less than after tillage and there is a general increase with increasing the operating speed of the tillage machine, this may be due to the destructive action of the machine and its speed on the soil structure.

The highest value was obtained in the case of using the combination unit at 5.02 km/h for all crops and each site, these results were agree with Saxton *et al.,* 1996.

2. Crop residue cover:

The percentage of crop residue cover was measured before and after tillage. Fig. 2 shows the crop residue cover percentage in relation to machine type and tillage forward speed. It is obviously that the value of crop residue cover decreased after applying all tillage treatments because of the inversion and cutting action of the tillage equipment on the residues. Also increasing the forward speed lead to reduce the percent of crop residue cover. The highest record was achieved with the chisel plow

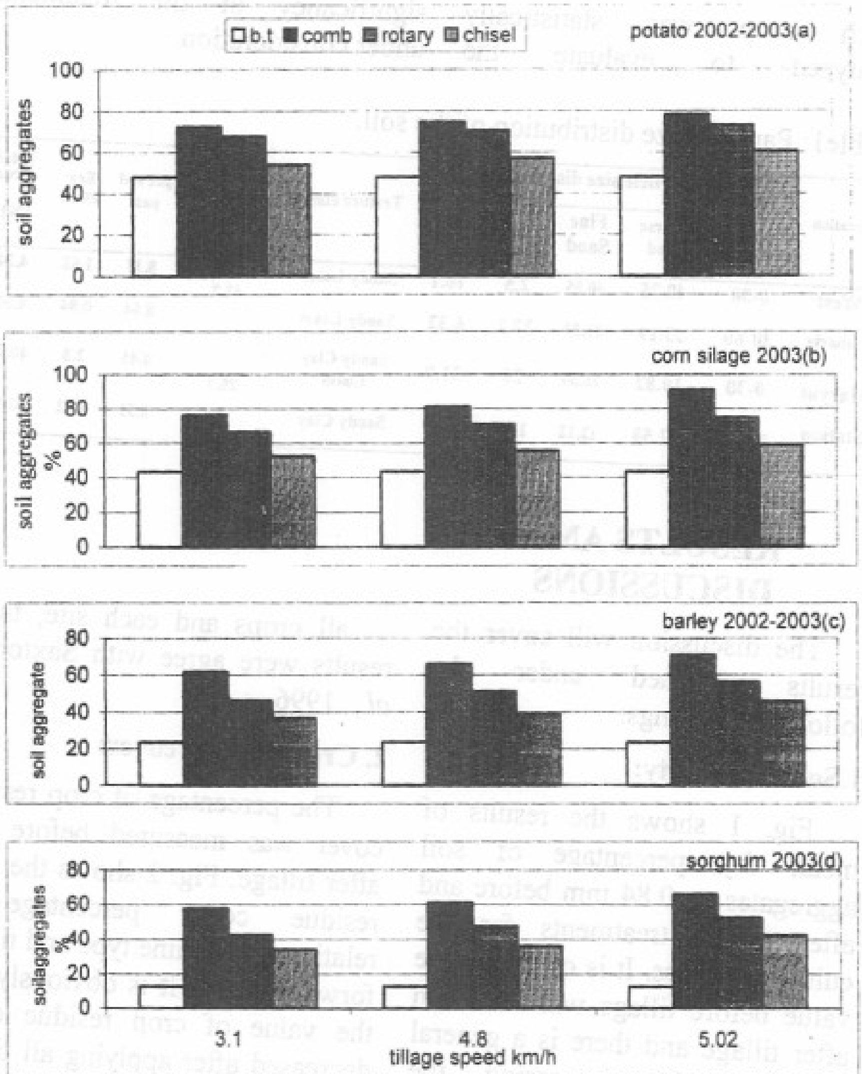

Fig. 1: Effect of tillage machine and forward speed on mean dry percentage of soil aggregates > 0.84 mm before and after tillage treatments for different cultivated crops. (a,b in West Nubaria site c,d in Maryut site).

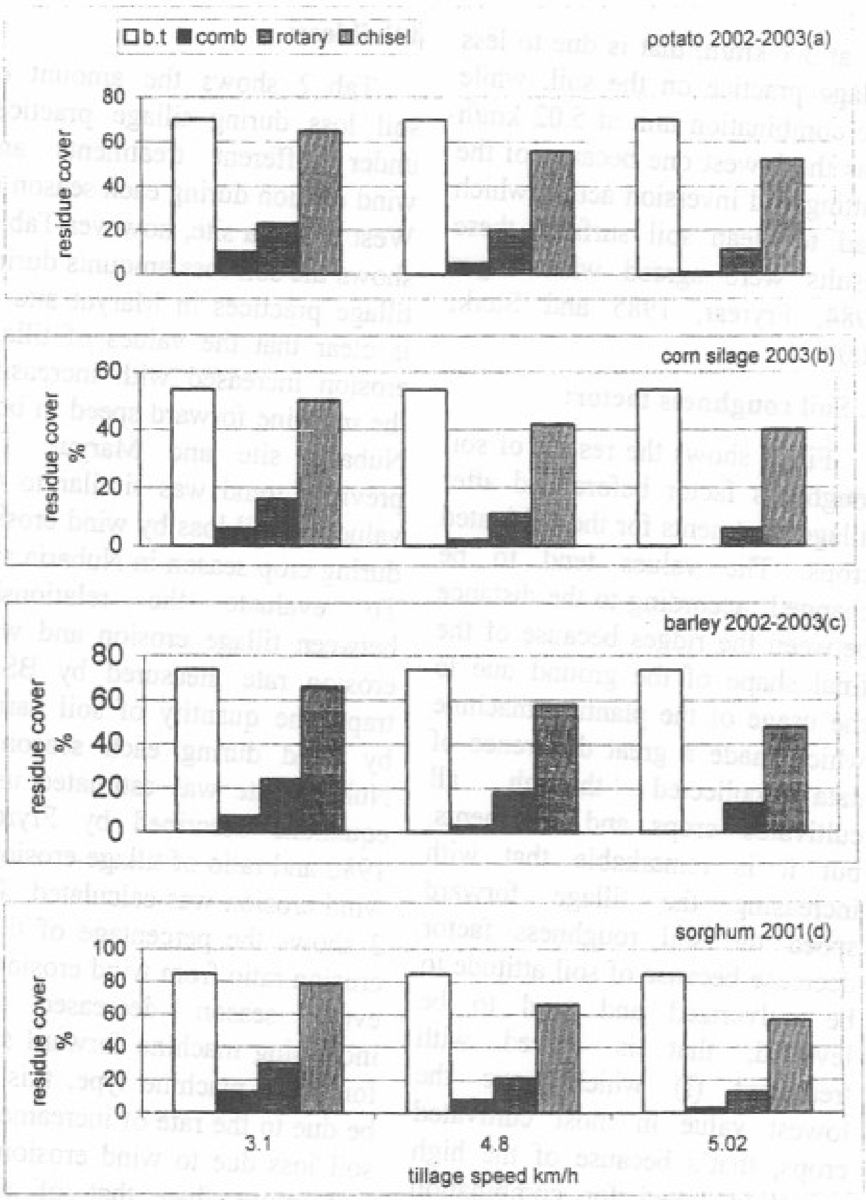

Fig. 2 : Effect of tillage machine and forward speed on crop residue cover before and after tillage treatments for different cultivated crops. (a,b in West Nubaria site c,d in Maryut site).

at 3.1 km/h, that is due to less tillage practice on the soil, while the combination unit at 5.02 km/h was the lowest one because of the cutting and inversion action which lead to clean soil surface, these results were agreed with Unger 1984, Fryrear, 1985 and Sterk, 2000.

3. Soil roughness factor:

Fig. 3 shows the results of soil roughness factor before and after tillage treatments for the cultivated crops. The values tend to be changed according to the distance between the ridges because of the final shape of the ground due to the usage of the planting machine which made a great difference of data collected through all cultivated crops and treatments, but it is remarkable that with increasing the tillage forward speed the soil roughness factor decrease because of soil attitude to be pulverized and tend to be levelled, that is agreed with treatment (I) which have the lowest value in most cultivated crops, that's because of the high operating speed for combination unit, which increase the state of levelling to the soil.

4.Soil loss:

Tab. 2 shows the amount of soil loss during tillage practices under different treatments and wind erosion during each season in West Nubaria site, however Tab. 3 shows the soil loss amounts during tillage practices in Maryut site. It is clear that the values of tillage erosion increased with increasing the machine forward speed in both Nubaria site and Maryut. The previous trend was similar to the values of soil loss by wind erosion during crop season in Nubaria site. To evaluate the relationship between tillage erosion and wind erosion rate measured by BSNE traps, the quantity of soil carried by wind during each season in Nubaria site was estimated using equations described by Fryrear, 1986 and ratio of tillage erosion to wind erosion was calculated. Tab. 2 shows the percentage of tillage erosion ratio from wind erosion for every season decreased with increasing machine forward speed for every machine type, this may be due to the rate of increament of soil loss due to wind erosion rate was more than that of tillage erosion for every machine type for both crops the combination unit at 4.8 km/h is exception.

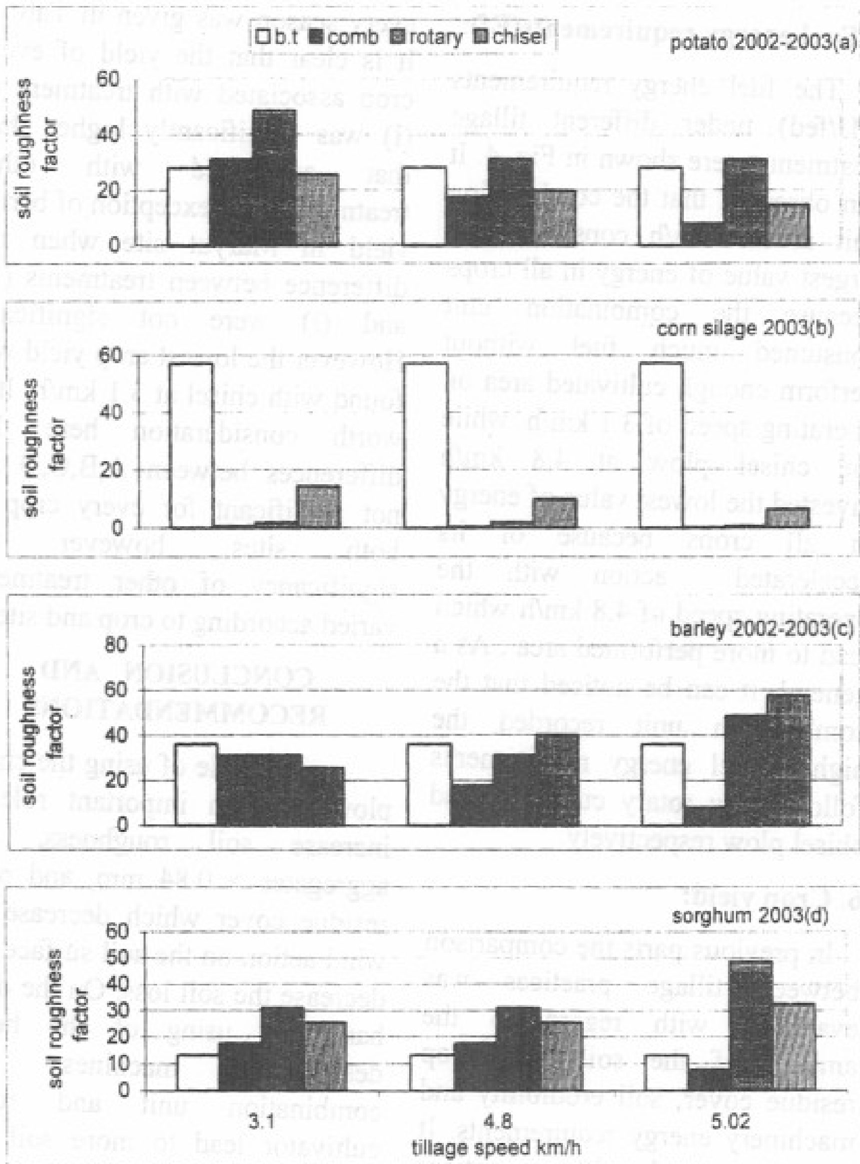

Fig. 3: Effect of tillage machine and forward speed on soil roughness factor before and after tillage treatments for different cultivated crops. (a,b in West Nubaria c,d in Maryut).

5. Fuel energy requirements(Ef):

The fuel energy requirements (MJ/fed) under different tillage treatments were shown in Fig. 4. It can observed that the combination unit at 3.1 km/h consumed the largest value of energy in all crops because the combination unit consumed much fuel without perform enough cultivated area on operating speed of 3.1 km/h, while the chisel plow at 4.8 km/h invested the lowest value of energy in all crops because of its accelerated action with the operating speed of 4.8 km/h which lead to more performed area . As a general, it can be noticed that the combination unit recorded the highest fuel energy requirements followed by rotary cultivator and chisel plow respectively.

6. Crop yield:

In previous parts the comparison between tillage practices was evaluated with regard to the amount of the soil loss, crop residue cover, soil erodibility and machinery energy requirements. It is well known that tillage practices are carried out to obtain the optimum crop yield and provide a suitable seedbed for plant growth. The effect of treatments under considerations on crop yield for every season was given in Tab. 4. It is clear that the yield of every crop associated with treatment of (I) was significantly higher than that associated with other treatments with exception of barley yield in Maryut site when the difference between treatments (H) and (I) were not significant. However the lowest crop yield was found with chisel at 3.1 km/h. It is worth consideration here that differences between A,B,C,D are not significant for every crop in both sites, however the significancy of other treatments varied according to crop and site.

CONCLUSION AND RECOMMENDATIONS

The role of using the chisel plow play an important role to increase soil roughness, soil aggregates > 0.84 mm, and plant residue cover which decrease the wind action on the soil surface and decrease the soil loss. On the other hand the using of the heavy destructive machines like combination unit and rotary cultivator lead to more soil loss specially with increasing the forward speeds. However the combination unit gave the heights values of crop yield as compared with both chisel and rotary

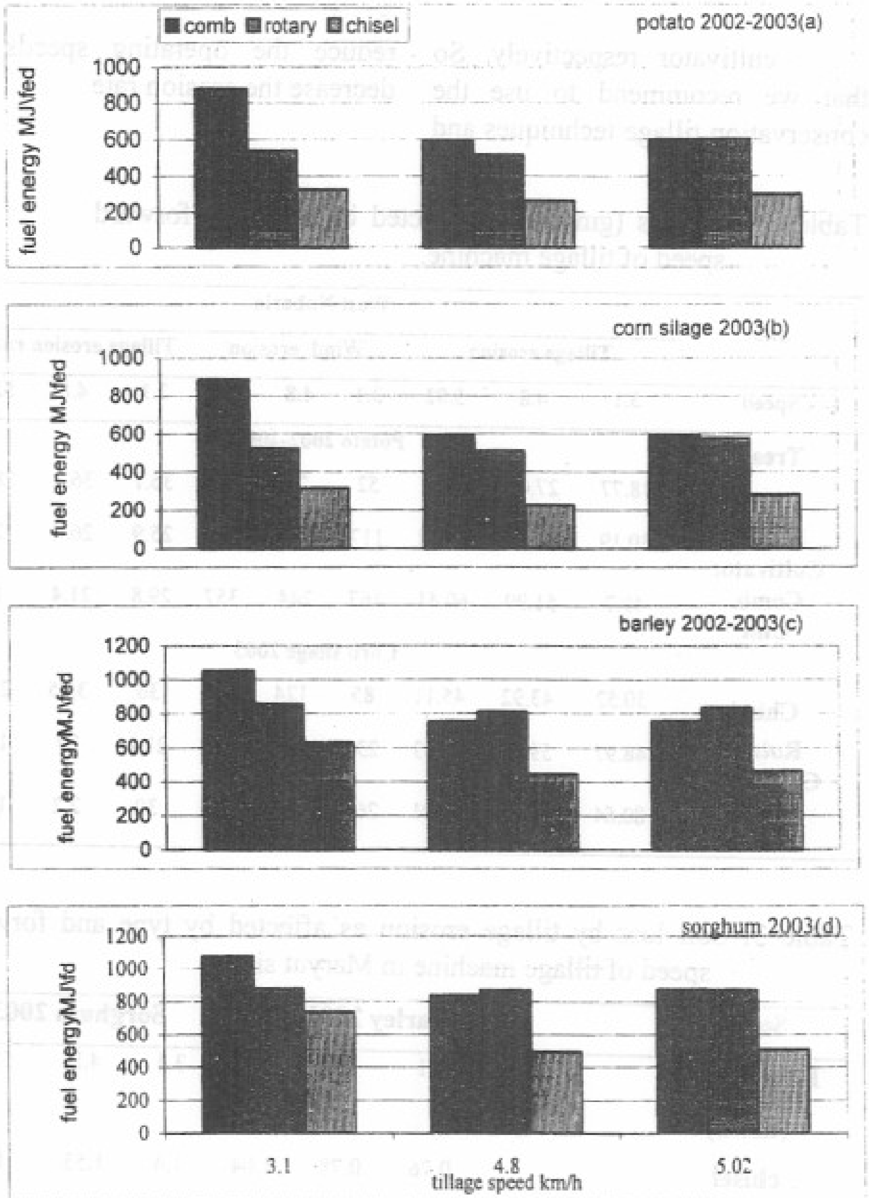

Fig. 4 : Effect of tillage machine and forward speed on the fuel energy requirements (Ef) MJ/fed. (a, b in West Nubaria c, d in Maryut).

cultivator respectively. So that we recommend to use the conservation tillage techniques and reduce the operating speeds to decrease the erosion rate .

Table 2: soil loss (gm/m^2) as affected by type and forward speed of tillage machine.

Site	West Nubaria								
	Tillage erosion			Wind erosion			Tillage erosion ratio		
Speed	3.1	4.8	5.02	3.1	4.8	5.02	3.1	4.8	5.02
Treat.	Potato 2002-2003								
Chisel	18.77	27.07	27.8	52	75	99	36.1	36.1	28.1
Rotary Cultivator	30.19	36.65	36.98	117	137	292	25.9	26.8	12.7
Comb. Unit	49.7	51.99	60.41	167	244	357	29.8	21.4	17
	Corn silage 2003								
Chisel	30.52	43.92	45.11	85	124	180	36	35.5	25.1
Rotary Cultivator	48.97	59.48	60.03	231	221	477	21.1	27	12.5
Comb. Unit	80.64	84.83	98.01	269	401	584	30	2.2	16.8

Table 3: Soil loss by tillage erosion as affected by type and forward speed of tillage machine in Maryut site.

Season	Barley 2002-2003			Sorghum 2003		
Treat./speed (km/h)	3.1	4.8	5.02	3.1	4.8	5.02
chisel	0.76	0.78	1.04	1.4	1.53	1.8
Rotary cultivator	0.89	1.14	1.18	2.03	2.23	2.31
Comb. Unit	1.21	1.83	1.93	2.64	3.57	4.21

Table 4:The statistical analysis of crop yield (kg/fed).

Treatments &Crops	A	B	C	D	E	F	G	H	I
					West Nubaria				
Potato (a) Nov-2002	5618 g	5887 fg	5985 fg	6019 fg	6025 fg	6383 ff	6797 f	8044 d	9732 c
Corn silage (b) May-2003	10439 e	10732 e	10872 e	10698 e	10853 e	10951 e	10816 e	26530 c	33389 a
					Maryut				
Barley(c) Dec-02	3274 e	3503 e	3401 e	3562 e	3823 d	3917 cd	4014 cd	4813 ab	4996 a
Sorgum(d) Jul-03	9503 f	9771 f	9897 f	9739 f	9881 f	9969 f	10856 e	24153 c	30398 a

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تأثير عمليات الحراثة على انجراف التربة بالرياح

تحت ظروف مناطق الاستصلاح الحديثة

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لدراســة تأثـير اســتخدام معدات الحراثة على انجراف التربة بالرياح أجريت عدة تجــارب حقلية في الفترة من أكتوبر ٢٠٠٢ إلى أكتوبر ٢٠٠٣ تحت نوعين مختلفين من الـتربة فـي منطقتي غرب النوبارية ومحطة بحوث مريوط التابعة لمركز بحوث الصحراء. وذلــك لتقيــيم الكمــيات المفقودة من التربة بفعل الرياح عند القيام بمجموعة من عمليات الحراثة تحت سر عـات امــامية (٣,١ ، ٤,٨ ، ٥,٠٢ كم/ساعة) وذلك باستخدام ثلاث معدات للحراثة هي (المحراث الحفار والعزاقة الدورانية والآلة المجمعة).

وقد أدى استخدام الآلة المجمعة إلى الحصول على أعلى القيم في مدى قابلية التربة للانجــراف بالرياح وبالتالي أعلى فاقد من التربة مقارنة بباقي المعدات الأخرى وكلما زادت ســرعات التشغيل كلما كان فاقد التربة بالرياح اكبر. وقد حققت الآلة المجمعة أعلى إنتاجية للمحاصــيل المــنزرعة مقارنـــة بباقي آلات الحراثة الأخرى المستخدمة. وقد أدى استخدام المحــراث الحفــار إلى الحصول على أعلى القيم في نسبة البقايا النباتية على سطح التربة وكذلــك اســتهلاك اكــبر كمــية مــن احتياجات طاقة الآلة مقارنة بباقي المعدات الأخرى المستخدمة.