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INFILTRATION RATE AND ITS RELATION TO IRRIGATION SCHEDULE FOR WATER ERODED AREAS IN EL-MAGHARA LOCATION, SINAI, EGYPT

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ABSTRACT

This study was carried out in El-Maghara Experimental Station of the Desert Research Center, Sinai. The purpose of this study was to investigate and evaluate the some soil physical and chemical properties, i.e. soil texture, soil infiltration rates, bulk density, available water and soil chemical properties of water eroded areas (runoff) and what are the best method for irrigation systems and the type of crops to be cultivated.

The area under studies is divided into three zones along water direction, eroded zone, transport zone and depositional zone. The first zone (eroded zone) is about 600 m long and represented by four soil profiles (1, 2, 3 and 4) the distance between them is 200 m (the first soil profile at point zero, start of water erosion). The second zone (transport zone) is about 680 m long and represented by four soil profiles (5, 6, 7 and 8), the distance between them is 170 m from the end of eroded zone. The third zone (depositional zone) is about 450 m long and divided to three soil profiles (9, 10 and 11), the first of which starts about 150 m apart from the end of the second zone (transport zone).

Results show that the values of infiltration rate vary from zone to zone and even within the same zone according to water direction. The values of infiltration rate at these zones range from 41.65 to 106.70 cm/hr, 23.62 to 30.60 cm/hr and 15.48 to 18.41 cm/hr for the 1 st, 2 nd, and 3 rd zones, respectively. All values of infiltration rate in the studied zones are very rapid and rapid. Also, the results point out that the gravel content is higher in the first zone than the second zone while being absent in the third zone. The percentage of fine fractions (silt, clay and silt plus clay) and concentrations of cations and anions increase along water direction, while the reverse is true with sand.

The data showed that the irrigation frequencies can be predicted for different crops according to soil infiltration rate, available water and soil texture.

Key words: Infiltration rate, Eroded zone, Transport zone, Depositional zone and Soil physical and chemical properties.

INTRODUCTION

The soil erosion by water is a serious problem in many parts of the world. On site damage, often reduces the potential of soil to produce crops by reduced water holding capacity, lost nutrients, degraded soil structure and reduced field soil uniformity, Ellison (1947); Stallings (1953); Beasley *et al*. (1984) and Knuti *et al*. (1984). They showed that the surface soil is the first part erosive by water erosion and the soil becomes poor in several minerals. Richter and Negendank (1977) showed that soils with 40 to 60 percent silt content are the most erodible. Voroney *et al*. (1981) stated that the decreases of organic mater can be considered erodible soil. Wischemier (1966) found that the total runoff per unit area was increased by increasing slope length and decrease of infiltration rate in the longer slope segments due to the physical change of the surface. Also, Young (1980) observed that, as slope percentage increases up to 10%, the percentage of coarse materials transported in runoff increased. Obi and Asiegbu (1980) stated that water erosion tends to change the surface soil texture toward the more coarse size particles. Morgan (1986) stated that the silt content is higher on the steeper slopes and there is a significant correlation between silt content and slope angle. He added that silt/clay ratio increases with distance. To reduce the water action or runoff tillage must be practice with proper planting system, Mueller *et al*. (1984); Shaffer (1985) and Freebairn *et al*. (1989).

MATERIALS AND METHODS

The current study was conducted in El-Maghara Agriculture Experimental Station of The Desert Research Center, Sinai. The soil under study is sandy to loamy sand and the percentage of CaCO3 is about 5.21 to 18.56%.

The areas selected for this study are divided into three zones according to the action of run-off and water flow. The first zone (eroded zone) is about 600 m long and represented by four soil profiles (1, 2, 3 and 4), the distance between each soil profile is 200 m, of which the first soil profile is at the starting point of run-off. The second zone (transport zone) is about 680 m long and represented by four soil profiles (5, 6, 7 and 8), the distance between each soil profile is about 170 m, and the first soil profile of the second zone is far about 170 m from the last soil profile of eroded zone. The third zone (depositional zone) is about 450 m long and represented by three soil profiles (9, 10 and 11), of which the first soil profile is 150 m apart from the last soil profile of the transport zone, the distance between soil profiles are 150m along the water direction.

11 tests of infiltration rates are conducted along water flow direction beside each soil profile and determined under constant head (7 cm) using double ring infiltrometer, as described by Klute (1986). The cumulative depth of infiltrated water D in cm as a function of time t, according to Philips two terms equation (1957 a, b).

$$D = St1/2 + At$$
$$I = ½ t-1/2 + A$$

Where; I is the infiltration rate, i.e., the steady state infiltration rate, and S and A are constants.

Also, irrigation frequencies for various plants were determined using meteorological data were collected from Egyptian Meteorological Authority. Cairo, Egypt, to compute ETo rates using Penman – Monteith equation according to FAO Penman – Monteith method as recommended by the FAO Expert Consultation held in May 1990 in Rome, Italy, by using CROPWAT , software version 5.7 (Smith,1992).

- Penman – Monteith Equation : (Smith,1993 and Allen *et al*. , 1998)

$$ETo = \frac{0.408\,\Delta\,(Rn - G) + \gamma\,\frac{900}{T+273}\,u2\,(es - ea)}{\Delta + \gamma\,(1 + 0.34\,u_2)}$$

Where :
ETo = reference evapotranspiration (mm day-1),
Rn = net radiation at the crop surface(MJm-2 day-1) ,
G = soil heat flux density (MJ m-2 day-1) ,
T = mean daily air temperature at 2 m height (ºC),
U2 = wind speed at 2 m height (m s -1) ,
es = saturation vapor pressure (Kpa),
ea = actual vapor pressure (Kpa),
es-ea = saturation vapor pressure deficit (Kpa),
Δ = slope vapor pressure curve (Kpa ºC-1),
γ = psychometric constant (Kpa ºC-1).

Also, crop coefficient (Kc) can be used to relate reference crop evapotranspiration (ETo) to maximum crop evapotranspiration (ETc) when water supply fully meets water requirements of the crop. ETc = ETo . Kc (Doorenbos and Kassam , 1986)

Particle size distribution is determined by using the pipette method as described by Piper (1950). Bulk densities were determined using the undisturbed soil cores, Klute (1986). Soil moisture retention at 0.06 and 15.0 bar were determined according to Klute (1986). Total carbonate was determined using Collin,s calcimeter, total soluble salts of the saturated soil extract and pH were determined according to Richards (1954).

RESULTS AND DISCUSSION

Climate:

The meteorological data of the studied area were collected from Egyptian Meteorological Authority. Cairo, Egypt, Table (1) reveal that the mean monthly temperature varies from 19.10 to 24.10 oC the relative humidity reaches up to 60.60 - 80.50 %, while the mean monthly evaporation ranges 3.1 to 5.3 mm, also the mean monthly surface wind speed varies from 3.7 to 5.3 m/sec and the mean monthly precipitation is about 1.2 to 3.4 mm.

Basic infiltration rate:

The basic infiltration rates were calculated, according to Philip's (1957). Data of the infiltration rates for soils are presented in Table (2) and Figures (1, 2 and 3).

The basic infiltration rates of the studied soils range between 15.48 and 106.70 cm/hr (rapid and very rapid). According to Taylor (1964), if the basic infiltration rate exceeds 12 cm/hr or the value of "n" exceeds 0.70, the soil is considered unsuitable for surface irrigation except under special conditions. However, the sprinkler or dripping systems are applicable for sandy soils.

In spite of the fact that basic infiltration rates are rapid and very rapid for all soil profiles studied, but they vary within and between zones. The results in Table (2) revealed that the basic infiltration rates decreased on passing from eroded zone 14.87 to 40.24 % at transport zone and to 15.92 at deposit zone. Between eroded and transport zones , the basic infiltration rates decreased between 43.29 and 71.13 %. While there decreases 39.44 and 44.06 % between transport and depositional zones. Also, the results showed that the basic infiltration rates between eroded and deposit zone decreased by 77.16 and 82.75 %. The relatively decreases of basic infiltration rates may be due to the increase of both silt and clay fractions and texture of soil changed from sand to loamy sandy, Tables (3, 4 and 5) with water direction precipitation.

Data also showed that the physical soil properties in Tables (3,4and 5) as well as soil moisture content %, bulk density (g/cm^3), CaCo3%, Coarse and fine sand, silt, clay% and gravel are vary from zone to zone and from layer to another, according to water runoff direction, therefore, the mean values of available water in eroded zone is vary from 4.09 to 5.29% , transport zone vary from 4.78 to 5.32% and depositional zone from 8.03 to 8.5%. Thus the values of available water percentages increases with water direction precipitation, due to increases of fine fractions (silt and clay).

Data also point out that the values of bulk density (g/cm^3) is relatively between 1.52 and 1.57 in the eroded zone, 1.56 and 1.65 in the transport zone and from 1.65 to 1.69 (g/cm^3) in the depositional zone. Hence the values of bulk density are increases with decreases of infiltration rate value, Talha *et al*.(1974) and Soni *et al*. (1985). The results also showed that the fractions of silt and clay in Table (3, 4 and 5) are increases with water direction precipitation, but the soil fraction of coarse sand decreases with water direction precipitation from eroded zone to deposited zone.

Gravel percentages by volume are divided to three groups i.e. coarse, medium and fine gravel, markedly noticed that the higher values of gravel are showed in eroded zone, but the lower values are showed in transported zone, while not found in deposited zone. The mean values of coarse, medium and fine gravels are relatively between 75.55 to 85.87 % in the eroded zone, between 73.48 to 85.54% in the transported zone and zero in the deposited zone. While declarable that the values of fine gravels are lower in the eroded zone than in the transported zone.

table1,2

fig1

fig2

fig3

table3

table4

table5

The results markedly revealed that (Tables 6, 7 and 8) the concentration of electric conductivity and the concentrations of anions and cations in the representative soil profiles increased with water direction.

Determination of irrigation frequencies:

The irrigation frequencies for the most predominant field crops and vegetables that are considered to be potentially grown in this region were calculated. The calculations are based on two parameters; a)-the depth of available water in the root zone and, b)-the monthly consumptive use for each crop during its growth season which was obtained from FAO Penman-Monteith equation by Allen *et al*. (1998) to estimate crop evapotranspiration (mm day-1).

The following equation was applied to estimate irrigation frequencies, Doorenbos and Pruitt (1984);

$$I = \frac{(P * Sa) . D}{ETc}$$

Where;

I = Irrigation interval, day.

P = Fraction of total available soil water,

Sa = Total available soil water, mm/m soil depth,

D = Rooting depth, m

ETc= Crop evapotranspiration, mm/day.

Table (9) shows that calculated irrigation frequencies vary according to the texture of soil, crop and growth season. For coarse sand; watermelon, tomato, cucumber, squash and peaches can be grown satisfactorily using sprinkler or drip irrigation systems, except for olives. In case of medium sand, the irrigation frequencies are longer than 9 days, surface irrigation under special conditions was applied for all crops in spite of the high infiltration rate.

In conclusion, the use of infiltration parameters and soil texture, also available water as indicators to the suitability of an irrigation system must be coupled with the data of irrigation frequencies for plants which might be grown in the area under study.

table6

table7

table8

table9

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معدل الرشح وعلاقته بجدولة الرى فى المناطق المعرضة للإنجراف بالمياه بمنطقة المغارة سيناء- مصر

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يهدف هذا البحث إلى دراسة الخواص الفيزيائية والكيميائية للأراضي المعرضة للانجراف بالمياه وذلك على طول خط الانجراف بغرض معرفة التدرج في الخواص الفيزيائية والمتمثلة في معدلات الرشح والثوابت الرطوبية والقوام والنسبة المئوية لكربونات الكالسيوم والكثافة الظاهرية الى جانب معرفة التدرج فى تركيز الكاتيونات والأنيونات والاملاح الذائبة الكلية ومدى أثر ذلك على جدولة الرى بالمنطقة ومعرفة أنواع المحاصيل المختلفة التى تجود تحت هذه الظروف.

لذلك : أجريت هذه الدراسة بمنطقة المغارة - سيناء التابعة لمركز بحوث الصحراء وتم تقسيم المنطقة على طول خط الأنجراف الى ثلاث مناطق حسب تأثير الأنجراف بالمياه على التربه:

1- المنطقة الآولى : وهى المنطقة المنجرفة بفعل المياه (Eroded Zone) وهذه المنطقة طولها ٦٠٠ متر وتم أخذ ٤ قطاعات تربة وكذلك أجريت ٤ أختبارات لمعدلات الرشح ، القطاع الأول أخذ فى نقطه بدايه الانجراف ثم كل قطاع يبعد عن الآخر مسافة ٢٠٠ متر فى اتجاه الانجراف بالمياه.

2- المنطقة الثانية : وهى تمثل منطقة الانتقال (Transport Zone) وطول هذه المنطقة ٦٨٠ متر وتم عمل ٤ قطاعات تربة وكذلك ٤ اختبارات لمعدلات الرشح والقطاع الاول يبعد عن نهاية منطقة الانجراف (Eroded Zone) بمسافة ١٧٠ متر وكل اختبار بعد ذلك يبعد بمسافة ١٧٠ متر على طول خط الانجراف بالمياه.

3- المنطقة الثالثة : وهى تمثل منطقة الترسيب (Depositional Zone) وطول هذه المنطقة حوالى ٤٥٠ متر وتم عمل ٣ قطاعات تربة بها وكذلك ٣ اختبارات لمعدلات الرشح وكل قطاع يبعد عن الاخر بمسافة ١٥٠ متر على طول خط الانجراف وأول قطاع يبعد عن نهاية المنطقة الثانية (Transport Zone) بحوالى ١٥٠ متر.

وقد توصلت النتائج الى ما يلى :

أولاً: وجد ان قيم معدلات الرشح كانت عاليه فى منطقة الانجراف (Eroded Zone) ثم تنخفض تدريجياً فى المنطقة الثانية (Transport Zone) ثم تقل بمعدلات كبيرة فى منطقة الترسيب وذلك على طول خط الانجراف بالمياه حيث انخفض معدل الرشح فى بدايه الانجراف من ١٠٦,٧سم/ساعة الى ١٥,٤٨سم/ساعة فى نهاية خط الانجراف.

كذلك أوضحت النتائج أن نسبة الحجارة والحصى كانت كبيرة فى المنطقة الاولى ثم انخفضت فى المنطقة الثانية ثم أنعدمت فى المنطقة الثالثة على طول خط الانجراف بالمياه كذلك أوضحت النتائج أن نسبة الحجارة والحصى كانت كبيرة فى المنطقة الأولى ثم أنخفضت فى المنطقة الثانية ثم أنعدمت فى المنطقة الثالثة على طول خط الأنجراف بالمياه.

أيضاً انخفضت نسب الرمل الخشن والرمل الكلى كلما اتجهنا الى منطقة الترسيب وعلى العكس اظهرت النتائج ان قيم السلت والطين ومن ثم السلت + الطين وكذلك الاملاح الذائبة وتركيز الكاتيونات والانيونات يزيد تدريجيا وبصورة ملحوظة مع اتجاه الانجراف بالمياه.

ثانياً: بالنسبة لحساب فترات الرى للمحاصيل المختلفة اظهرت النتائج ما يلى:

1- انه بالنسبة للقوام الخشن تقل فترات الرى للمحاصيل المختلفة مثل البطيخ والطماطم والشمام والكوسة والفستق والخيار والزيتون وايضا مع المواسم المختلفة بمعنى تختلف فترات الرى تبعا للقوام الخشن وشهور الزراعة فى الصيف أو الشتاء.

2- بالنسبة للقوام المتوسط النعومة فقد أظهرت النتائج زيادة فترات الرى عن القوام الخشن وأيضاً تختلف حسب مواسم الصيف أو الشتاء.

لذلك يوصى باستخدام الرى بالرش أو بالتنقيط فى فترات الرى القصيرة بعكس الزيتون الذى يتطلب فترات رى طويلة يوصى برى سطحى أفضل من الري بالرش أو التنقيط لذلك توصى هذه الدراسة بالاخذ بقيم معدلات الرشح والثوابت الرطوبية مع قوام التربه فى تطبيق نظم الرى المختلفة وحساب فترات الرى للمحاصيل التى تجود بهذه المناطق تحت الدراسة.