EVALUATION OF TILLAGE EROSION UNDER NORTH-WEST COASTAL REGION OF EGYPT

By

ABOUELNADAR ELSAID MASSOUD IBRAHIM SALEM

B.Sc. Agric. Sc. (Agric. Mechanization), Kafr El-Sheikh University, 2006.

A Thesis Submitted in Partial Fulfillment

Of

The Requirements for the Degree of

MASTER OF SCIENCE
in

Agricultural Sciences
(On Farm Machinery and Power Engineering)

Department of Agricultural Engineering

Faculty of Agriculture

Ain Shams University

2017

Approval Sheet

EVALUATION OF TILLAGE EROSION UNDER NORTH-WEST COASTAL REGION OF EGYPT

By

ABOUELNADAR ELSAID MASSOUD IBRAHIM SALEM

B.Sc. Agric. Sc. (Agric. Mechanization), Kafr El-Sheikh University, 2006.

This thesis for M.Sc. degree has been approved by:

Dr. Mahmmoud Ahmed Mosallam …………………

Prof. Emeritus Agricultural Engineering, Faculty of Agricultural Engineering, ELAzher University.

Dr. Mahmmoud Mohammed Hegazi …………………

Prof. Emeritus of Agricultural Engineering, Faculty of Agriculture, Ain Shams University.

Dr. Mohamed Nabil El Awady …………………

Prof. Emeritus of Agricultural Engineering, Faculty of Agriculture, Ain Shams University.

Date of Examination: 5 / 10 / 2017

EVALUATION OF TILLAGE EROSION UNDER NORTH-WEST COASTAL REGION OF EGYPT

By

ABOUELNADAR ELSAID MASSOUD IBRAHIM SALEM
B.Sc. Agric. Sc. (Agric. Mechanization), Kafr El-Sheikh University, 2006.

Under the supervision of:

Dr. Mohamed Nabil El Awady
Prof. Emeritus of Agricultural Engineering, Department of Agricultural Engineering, Faculty of Agriculture, Ain Shams University. (Principle Supervisor)

Dr. Essam Ahmed Soliman El Sahhar
Prof. Agricultural Engineering, Department of Agricultural Engineering, Faculty of Agriculture, Ain Shams University.

Dr. Mohamed Mohamed Abdo Wassif
Researcher Prof. Emeritus of soils, soil conservation Dept. Desert Research Center.

ABSTRACT

Abouelnadar Elsaid Massoud Ibrahim Salem: Evaluation of Tillage Erosion under North-West Costal Region of Egypt. Unpublished M.Sc. thesis, Department of Agricultural Engineering, Faculty of Agriculture, Ain Shams University, 2017.

Tillage erosion has been identified as an important global soil degradation process that has to be accounted for when assessing the erosional impacts on soil productivity, environmental quality or landscape evolution. No study has been carried out on tillage erosion associated with chisel tillage systems in the North West coastal zone in Egypt, and there is a need to examine tillage erosivity of chisel tillage and the effect of slope gradient on tillage translocation. With both tillage and water erosion occurring in a cultivated topographically complex landscape, it is valuable to investigate the relative contributions of and the possible linkage and interactions between these two erosion processes. Tillage translocation causes the mixture of subsoil into the till-layer, which may considerably affect soil properties and therefore the related biophysical processes. In this study, using plot tracers, we examined tillage translocation caused by four chisel tillage systems: Chisel tillage of a consolidated soil under stubble vegetation (primary pass) up and downslope tillage, Chisel tillage of a consolidated soil under stubble vegetation (primary pass) contour tillage, Chisel tillage of a freshly tilled, loosened soil (secondary pass) up and downslope tillage and Chisel tillage of a freshly tilled, loosened soil (secondary pass) contour tillage in the North West coastal zone, Egypt. The experimental results show that the average displacement distance is not only a function of slope gradient, but also of soil condition, tillage depth and tillage speed. Five bounded plots were used to examine the impacts of chisel tillage systems on water erosion. The results imply that soil losses by tillage and water erosion tended to increase with increasing tillage intensity. Experiment results show that chisel tillage in North-Western Coast, Mersa Matrouh city, at EL-Qasr region is erosive, leading to annual tillage erosion rates exceeding 7 Mg ha^{-1} locally. In order to validate the soil translocation model developed by (**Van Muysen *et al*., 2000**), we used the data available in this study. This validation showed that variations in tracers displacement distance can be successfully predicted, but their absolute magnitude is probably also controlled by tillage implement characteristics. Considering the widespread use of tillage practices, the high redistribution rates associated with the process and its direct effect on soil properties, it is clear that tillage erosion should be considered in soil landscape studies.

Key words: Soil erosion, tillage erosion, chisel tillage, soil translocation and water erosion.

ACKNOWLEDGEMENT

I would like to express my deep appreciation and gratitude to **Prof. Dr. Mohamed Nabil El Awady**, Prof. Emer. of Ag. Eng., Fac. Ag., Ain Shams U. for suggesting the problem of study and for his kind supervision throughout this work. The author is grateful for his valuable discussions, which helped to finalize this work.

The author wishes to express her sincere gratitude and appreciation to **Prof. Dr. Essam Ahmed Soliman El Sahhar**, Prof. of Ag. Eng., Fac. Ag., Ain Shams U., for kind supervision, continuous encouragement and valuable advices throughout this work.

The author wishes to express her sincere gratitude and appreciation to **Prof. Dr. Mohamed Mohamed Abdo Wassif,** Researcher Prof. Emer. of soils, soil conservation Dept. D. R.C., for supervision, problem suggestion, continuous encouragement, valuable advices throughout this work, kind help and for reviewing the manuscript.

Deep thanks are also extended to **Prof. Dr. Saad Fawze Tadres Sharkawy,** Researcher Prof. of soil, soil conservation Department, Desert Research center (D.R.C) for his valuable scientific assistance and advice throughout the research, help during writing this thesis.

Special thanks to all staff members of the soil conservation Department, Desert Research center (D.R.C) for their kind help.

Special thanks to all staff members of the Ag. Eng. Dep., Fac. of Ag., Ain Shams U., for their kind help.

Finally, deepest appreciations are going towards my family for their loving encouragement.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Soil erosion causes the loss of the fertile topsoil and leads to land degradation. The redistribution of soil within landscapes due to soil erosion also changes soil properties at a given point, which has implications on other biophysical processes such as nutrients and pesticides movement. In agricultural land, soil erosion is accelerated due to human activities. Based on the force driving the process, soil erosion is classified as water, wind and tillage erosion.

Tillage is one of the fundamental practices of agricultural management. It is the procedure by which man disturbs, overturns and rearranges the soil to create favorable soil physical conditions for crop growth. The tillage operations loosen, granulate, and crush, of even compact the soil particles. Any tillage operation that changes soil bulk density in turn modifies pore size distribution, water holding capacity, infiltration rate, penetration resistance and soil aeration. Since each soil type and cropping system responds differently to tillage. Tillage system desirable in one location, may be a complete failure in another location.

The studies of water and wind erosion started in the 1930s, with the establishments of Universal Soil Loss Equation (USLE) (**Wischmeier and Smith, 1965**) and Wind Erosion Prediction Equation (WEQ) (**Chepil *et al*., 1962**) as the respective milestones. The recognition of tillage erosion can be dated back to 1920s (**Aufrère, 1929**). (**Mech and Free, 1942**) measured the displacement of soil by tillage and concluded that significant amount of soil was moved downslope by tillage. However, for decades, water and wind erosion was assumed to be the major forms of soil erosion on cultivated land. Tillage was considered as an important factor that influences soil erodibility but the direct movement of soil by tillage was ignored (**Govers *et al*., 1999**).

Traditionally, soil erosion by water,wind, and gravity has been considered the only driving forces of soil redistribution. Different soil erosion processes have different spatial signatures in the landscape. Water erosion primarily causes soil loss in mid-slopes or troughs (where water flows are concentrated); wind erosion is relatively uniform at the field scale; and tillage erosion primarily causes soil loss on hilltops (convexities) and soil accumulation in footslopes and depressions (concavities). Typical field evidence of soil erosion in cultivated land is eroded hilltops. While the importance of water erosion is widely recognized, tillage erosion is also known as an important component of total soil erosion in some soils. Tillage erosion rates can be higher than water erosion rates in hilly croplands, which rely on soil erodibility (**Blanco and Lal, 2008**). Thus, tillage erosion modifies the spatial patterns of landform elements while inducing changes in soil properties.

Recent studies have unraveled interactions among differing scenarios of slope gradients, and tillage operations (e.g., direction, depth, speed), tillage methods (e.g., hoeing, chisel plow, animal traction), and soil properties (e.g., soil constituent, soil aggregation) that affect the magnitude of tillage erosion under either controlled or field management systems. In the early 1990s, researchers from different parts of the world carried out field experiments to examine soil movement by tillage and suggested that tillage erosion is a major cause of these observed patterns of soil redistribution in cultivated field (**Zhang *et al*., 2009**).

Tillage erosion is the redistribution of soil that occurs within a landscape as a direct result of tillage. Tillage erosion is caused by the variation in the amount of soil that is displaced by tillage. The displacement of soil by tillage is called tillage translocation. Tillage translocation is primarily determined by local slope gradient and, therefore, tillage erosion is dependent on the change of slope gradient. Typically, tillage results in the progressive downslope movement of soil, causing severe soil loss on convexities and the upslope field boundaries and soil accumulation in concavities and downslope field boundaries (**Govers *et al*., 1999**). There are more convexities and concavities on topographically complex landscapes than on topographically simple landscapes, so that tillage erosion is more intensive on topographically complex landscapes than on topographically simple landscapes.

Lindstrom *et al*. (1992) were among the first who carried out systematic experimental studies on tillage translocation and tillage erosion. These researchers established a simple model to simulate tillage translocation. This model has been adopted and further developed by several other researchers and is generally referred to as a diffusion (**Govers *et al*., 1994**). The original version of this model was simply a linear function between tillage translocation and slope gradient. A single parameter, the tillage transport coefficient, was used to characterize the erosivity of the examined tillage operation. Later on, other factors such as tillage depth, tillage speed and soil conditions were introduced into this model (**Van Muysen *et al*., 1999, 2002**). The magnitude of tillage erosion depends on tillage erosivity, the erosivity of the tillage operation, and landscape erodibility, the erodibility of the landscape (**Lobb and Kachanoski, 1999a**). Tillage erosivity is determined by the design of the tillage implement (i.e. the type of equipment, the arrangement and geometry of the cutting tools), and how the tillage is operated (i.e. tillage frequency, tillage speed and depth, the match between the tractor and the implement and the behavior of the operator). Any field operation that disturbs soil has the potential to cause tillage erosion.

The objectives of this study were:

1) To assess the erosivity of chisel tillage systems in the North West coastal zone, Egypt.
2) To assess the tillage erosion rates of individual tillage pass and the annual tillage erosion rates.
3) To examine the impacts of chisel tillage systems on water erosion.
4) To investigate the effect of slope gradient, tillage depth, tillage speed and tillage direction on tillage translocation.
5) To validate the proposed mathematical model by (**Van Muysen *et al*. 2000 and Awady and Salem, 2017**) used in mean displacement distance of the tracers in the direction of tillage prediction.