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Soil Dislocation on Slopes as a Result of Tillage

Since the eighties at the latest, soil conservation has been in the limelight of ecological policy discussions, due to increased consciousness about continuous substance impairment by waste matter, erosion, soil compaction and sealing. Professional literature underlines that soil dislocation on arable land caused by tillage can be of considerable importance. The summary below describes the relationships of tillage caused soil displacement, by illustrating the influencing factors, methods of quantification and possible approaches to prevention.

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Keywords

Tillage erosion, net soil dislocation, measuring methods, prevention

Grounds hold a central position in terrestrial ecosystems since it represents a limited and non-renewable natural resource. For this reason in particular the German Bundestag's commission of enquiry into the Protection of People and the Environment (1997) formulated as a high-level environmental goal "the preservation or regeneration of the function of grounds and careful handling of grounds as a limited resource." Similar goals will also be set and demands made in the future that go beyond existing laws and regulations and they will be implemented accordingly.

It is therefore appropriate to review existing tillage strategies and implements from the viewpoint of sustainability. Since in contrast to the soil-movement by water and wind, the dislocation of soil by tillage has scarcely been researched, it shall be discussed in more detail in the following.

Tillage erosion

Tillage erosion is understood to refer to the displacement of grounds and hence the loss of soil and accumulation of soil on slopes of various shapes used for agriculture as the result of the use of tillage implements [1]. The cause of this is mechanical intervention by tillage implements in the tillage horizon. All mechanical tillage in a horizontal direction leads to the dislocation of soil. If the dislocation occurs in the direction of the downward slope, this can lead to tillage erosion.

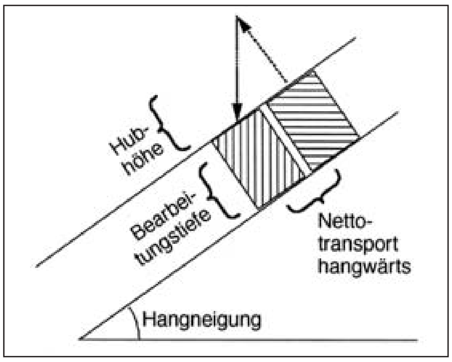

Fig. 1: Dislocation of a representative soil cube during cultivation [2]

The causes of this are all loosening tillage measures that raise the topsoil. On sloping surfaces this occurs vertically relative to the surface of the ground. Then the soil falls back but now vertically to the horizontal (*Fig. 1*). Net transportation downhill occurs as a result of the different directions of the two vectors.

The rate of soil removal or soil accumulation is determined by the change of gradients of slopes between neighbouring segments of slope. As a result of this process, we find that soil is lost from convex slope areas and accumulated on concave slope areas [3].

Influencing factors

The extent of tillage erosion is dependent on various influencing factors. Besides slope morphology and slope angles as factors specific to the location, the condition of the soil at the time of its tillage, for instance in terms of the density of layers, ground moisture, structure and organic substance has a significant impact [4]. Other parameters are the speed of working and the method of transport, the depth of working and the tillage implement or tool used. It is established that the level of tillage erosion is heavily dependent on the parameters mentioned and turns out to be different for different types of process and implement.

In the end, the soil movement caused is the result of the individual tillage activities with their specific dislocation rates. Here the net soil displacement rate is closely associated with the direction of working uphill or downhill or parallel to the slope, that is along the contours and with the soil removal equipment facing uphill or downhill (*Fig. 2 and 3*). Rates of erosion and dislocation from tillage may exceed 10 tonnes/hectare and year on slopes with a clear convex shape, when using a plough and working uphill and downhill [5]. In Canada, the erosion from tilling the land accounts for over 70% of all soil loss [6].

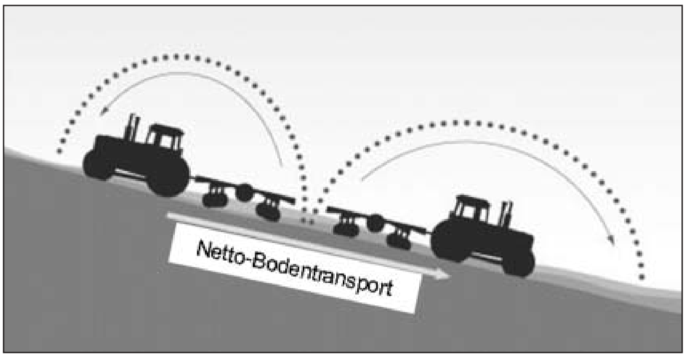

Fig. 2: Soil dislocation through tillage (cultivation in fall line)

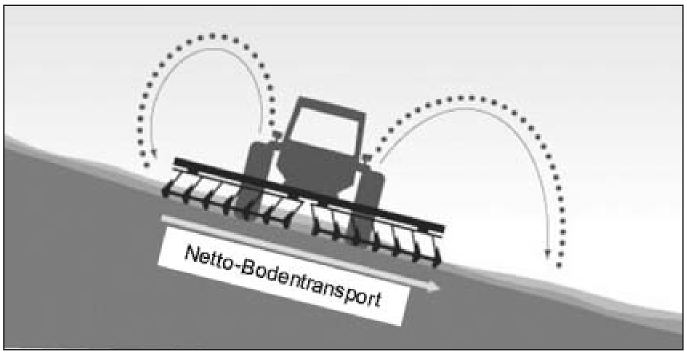

Fig. 3: Soil dislocation through tillage (cultivation along contour lines)

Measurement methods

The reports in the literature show variations in the measurement methods for determining erosion from tillage. Winnige [7] for instance uses tracers that consist of coloured gravel with a diameter of 4 mm and which are introduced into plots of sizes 1•0.2•0.3 m.

After the land has been worked, tracer concentrations are determined, taking into account the tracers introduced and recovered, from which the volume of soil moved can finally be calculated. Lobb et al. [8] use Caesium 137 (^{137}Cs) as a tracer. Here the ground is marked with ^{137}Cs within defined measurement blocks and after the land is worked, the spatial distribution of the relative concentration of 137Cs is used to measure the level of soil dislocation with the aid of a gamma spectrometer. Another approach is chosen by Govers et al. [5] who use numbered aluminium cubes with edge lengths of 15 mm as test bodies that are detected by a metal detector after the tillage in order to determine the soil dislocation.

Impact of tillage systems

A large proportion of the trials carried out as described in the literature on soil dislocation as a result of tillage are concerned with the conventional tillage implements, especially the mouldboard plough. Comparative trials of conventional and conservation tillage, plough versus disc harrow, attest a higher average distance of dislocation and a higher total dislocated weight of soil for conventional tillage.

However, it is a surprising fact that to date no trials with the use of a plough parallel to the slope and the soilmoving implement pointing uphill have been carried out to date. It is precisely this way of using a plough that is put forward by many of those involved on a practical level as an argument in favour of conventional tillage as opposed to conservation tillage.

Since the positive effects of conservation strategies for tillage are sufficiently well documented with regard to ecology, economy and sustainability and in particular to the reduced susceptibility to water erosion [9], it is appropriate to specify strategies for reducing soil dislocation on slopes with the use of conservation tillage technology in more detail.

The minimisation of the tillage depth or the intensity of tillage in the form of reduced frequency of tillage has a positive impact on any soil dislocation on slopes. Consequently it would be entirely logical to manage arable land or sections of it above a defined minimum angle of slope by direct sowing without working the land at all.

Another approach is represented by the redesign or improvement of work implements for conservation tillage. For example, one person with practical experience has produced ideas and implemented them with regard to the design of an implement for actively moving soil uphill when working along contours by means of a cultivator/disk harrow combination with disks elements that can be rotated.

Outlook

It is precisely in the context of the present, new socio-political and global economic regulations - regarding the concept of sustainability - that it seems appropriate to make topics, which have been unpopular to date, central to the debate. With the example of soil dislocation as a result of tillage, it is quite clear that there is a need for further research activities in agricultural techniques. New measurement methods, or ones easier to implement, for determining soil dislocation and the revision and redesign of tillage implements and tillage systems offer approaches in this connection.

Literature

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