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Erosion Protection by Site-Specific Soil Tillage

Extended Approaches for Prevention

Precision farming offers very promising solutions for minimizing erosion on cropland. Till now the main deficit of site-specific methods has been a lack of the data required for decision making. The only solution is more tests and the specific knowledge they generate. Ecological, economical and agronomical parameters must be included, to incorporate all the complex interrelations.

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Extreme weather and the resulting consequences, such as the flooding of the Elbe River in 2002, often raise public discussions about influences and effects of agricultural production methods on the environment.

Both scientific circles as well as farmers increasingly recognise that land erosion represents the major problem area for agricultural land protection both worldwide and in Germany. Land erosion results in loss of arable land, humus and nutrients and ultimately leads to a decrease of the productiveness of the soil. This is generally a slow process, the full scope of which often remains unrecognised [1]. In addition to „on site damages“ occurring on the surfaces affected by the dislocation processes of the land, „offsite damages“ exist as well. [2]. In addition to siltation, eutrophication and toxification of bodies of water, they also have significant financial consequences which are a burden to the economy.

Therefore, the government has established the Federal Land Protection Act (BBodSchG). It contains regulations against the origin of harmful land modifications. Based on this act, the agriculture is obligated to comply with the principles of good agricultural practice, outlined there in detail in § 17.

In addition, Europe has implemented the cross-compliance obligations in 2005 which include corresponding provisions to prevent erosion.

The second pillar of the EU agrarian reform is considered an additional instrument within which land-protection methods such as mulch-based and direct sowing are financially supported at country-level and co-financed by the EU.

Erosion prevention through precision agriculture

Conservation tillage, i.e. the consequent renouncement of using ploughs, is considered the most effective measure of preventive agricultural land protection [3].

In addition to the fundamental implementation of conservation tillage treatment methods, technical developments within the area of precision agriculture open new options for sustainable, erosion-reduced land cultivation. The central element is the variation of tillage depth with direct effects on the intensity and ultimately the degree of ground cover.

In many cases and for many sites, ground coverage of 30 to 50 % provides sufficient erosion protection [4]. This fact can be implemented by means of suitable strategies for site-specific tillage, taking into consideration naturally occurring heterogeneities and associated management zones.

Basic trials

In a field test conducted in 2005, different tillage depths and tools were compared in terms of the resulting ground coverage, infiltration and surface runoff. The tests were conducted in the „Lösshügelland” with its periglacial loess lands, located in mid-Saxony. Official consultants particularly focus on the site-adjusted and erosion reducing tillage treatment methods to be evaluated and propagated in the trial area. The motivation is mainly based on the severe erosion risk of the fields. Approximately 450,000 hectares are potentially at risk in Saxony [5].

Based on the above, five different tillage intensities (depths) were conducted in the field test regarding basic tillage within a randomised large parcel of land. They were repeated three times each.

The main pilot tool used was a cultivator-disk harrow-combination by Amazone BBG (Centaur), with the following three tillage depths: 5 to 10 cm, 10 to 15 cm and 15 to 20 cm.

A stubble cleaner plough (Kverneland) and a digger plough (Gassner) were used for comparison purposes, with tillage depth ranges of 10 to 15 cm and 15 to 20 cm.

Figure 1 illustrates the degrees of ground cover as a result of the tillage intensity and depth, emphasising the significant differences within the variants.

Following the optimisation of the rape seed crop, overhead irrigation tests for the infiltration behaviour were conducted on the

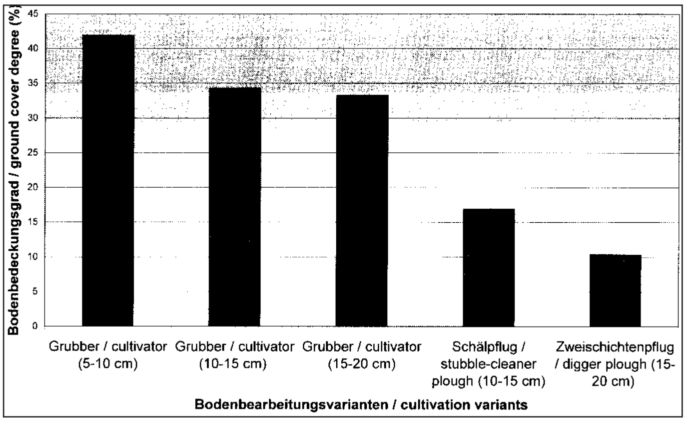

Fig. 1: Resulting ground cover degrees after rape seeding

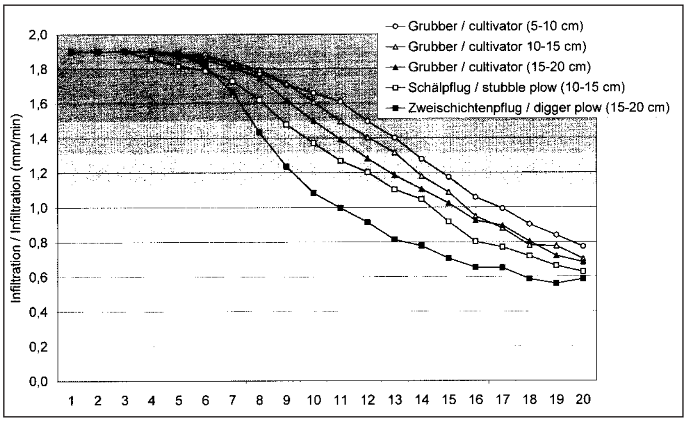

Fig 3: Infiltration curves

test land for a defined slope of 9 %. A mobile irrigation simulator (irrigation surface: 1 m^2) was used to simulate heavy precipitation (*Fig. 2*). A swivelling slot nozzle (type Veejet 80/100) was used to control the irrigation quantity and intensity. A precipitation quantity of 38 mm with an irrigation intensity of 1.9 mm•min^{-1} and a duration of 20 minutes was selected. The surface runoff and the eroded soil were collected at one minute intervals during the irrigation simulation and the water quantity determined by means of gravimetric measurements before and after evaporation of the water. To determine the infiltration rate, the surface runoff rate was subtracted from the precipitation intensity.

Effects on the infiltration behaviour

The results to the question to what extent the tillage treatment intensity affects the infiltration behaviour and ultimately the erodability of land, are illustrated in *Figure 3*. Significant differences as a result of the treatment intensity and the tools used to treat the land are observed after 6 minutes of irrigation. For longer periods of precipitation lasting 10 minutes, the cultivator variants show different infiltration developments, dependent on the tillage depth. The different ploughs, in particular the double plough, possess the smallest infiltration rate and analogously the highest surface runoff. From the point of view of erosion protection, conservation tillage treatment strategies are considered better in this respect. However, corresponding effects require the consequent, long-term implementation of the method [6].

Site-specific regulation of tillage depth dependent on the straw yield and relief

Corresponding algorithms need to be generated to realise a site-specific control of the tillage depth dependent on the straw yield and relief. Current information and records about the grain yield are crucial. Therefore, the harvest should be georeferenced using a corresponding technique. The straw and chaff quantities remaining on the field can be calculated taking into consideration the crop - and type-specific parameters and be displayed in map format. Within this context, the implementation of a tillage depth variation controlled online by means of suitable sensor technology is conceivable. Because the currently available sensor systems only inadequately record the actual straw quantities on the field, the mapping method is preferable.

The existing relief plays a major role in the development of erosion. The lasting implementation of erosion-reducing tillage treatment methods therefore requires the consideration of the relief via mapping or online methods. If no digital terrain models are available for the surface to be treated, the online method with the use of suitable inclination sensors represents the method of choice.

Outlook

The site-specific variation of the tillage depth represents a promising approach for erosion protection. Additional field tests at different sites are scheduled to widen the current results and to review their transferability.

Fig 2: Used semiportable rainfall-simulator

Concomitant vegetation-related analyses are used to clarify the question to what extent such methods affect crop farming parameters and ultimately the yield.

This approach is intended to provide further reaching decision making criteria and ultimately to support agricultural practice with actual recommendations for actions based on defined algorithms.

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