Istituto Sperimentale per lo Studio e la Difesa del Suolo

International Conference

Sustainable Soil Management for Environmental Protection Soil Physical Aspects

Abstracts

Florence, Italy 2-7 July 2001

Organized by

Istituto Sperimentale per lo Studio e la Difesa del Suolo

International Union of Soil Science

Società Italiana della Scienza del Suolo

EurAgEng - Field of interest on Soil and Water

International Commission of Agricultural Engineering

Under the high patronage of

Ministero delle Politiche
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With the contribution of

European Commission
Fifth Framework Programme for RTD "Quality
of life and Management of Living Resources"

European Soil Bureau
European Commission JRC - S.A.I.

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The ground pressure exerted by agricultural machines

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Abstract

The problems of soil and subsoil compaction caused by the traffic of agricultural machines have been thoroughly discussed during the last 40 years. However, in spite of the continuous warnings of the scientific community, the industry keeps manufacturing heavier and heavier machines (especially tractors, trailers and harvesting machines).
The aim of this paper is to survey the overall mass of these machines and its distribution, number of axles, type and size of tyres, their contact area, in order to find the range of ground pressures exerted and to give an idea of the potential soil damages.

Key words: soil, compaction, tyre, traffic

Calculation of pressure propagation in the soil: a simple model approach for the agricultural practice

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Abstract

Pressure propagation underneath the ploughing layer plays an important role in subsoil compaction caused by heavy agricultural machinery. To date, there is no reliable data available to be used in practice because there are numerous different calculation models and the measuring methods are quite controversial. The aim of this study consisted in examining the various calculation models by means of adjusted measuring data, taking into account soil stiffness, and in suggesting a practicable model approach. Within the scope of 6 years of field trials, the mean stress was measured by means of Bolling probes under different soil conditions, loads and depths (20, 40, 60 cm). The measuring technique was then tested on sand by means of a plate penetrometer (so-called Bevameter with vertically applied pressure). The pressure measured in the probes was lower than the pressure measured by means of the Bevameter. This result can be explained by two phenomena: the deformation resistance of the rubber head of the Bolling probes and the moving of the Bolling probes with the surrounding soil fraction. On the basis of the results of Bevameter measurements, the Bolling probe values were adjusted by means of a correction factor.
The measuring values were then compared to different model approaches serving to calculate the vertical stress σ_z; measuring results coincide best with the results of the Newmark equation including a concentration factor of 2.
To take into account the soil stiffness, an equivalent contact pressure was calculated by means of a mathematical approach according to Newmark on the basis of values measured at a depth of 20 cm and compared to the measured contact pressure (wheel load, measured contact area). The higher the coefficient K (equivalent contact pressure / measured contact pressure), the more plastic the soil and the higher the deformation. The pressure is concentrated in the middle of the wheel axle and increases.
Given a coefficient of 1, the ploughing layer is considered as hard, in case of a coefficient of 1.5 as half hard and in case of a coefficient of 2 as soft. This qualitative classification can be specified on the basis of soil moisture content, soil texture, vegetal plant cover and penetrometer resistance.

Key words: agricultural machinery, pressure propagation, equivalent contact pressure.

Influence of tyre inflation pressure on stress and displacement in the subsoil

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Abstract

High wheel load induces a risk for subsoil compaction. In principle, it could be avoided by reducing ground contact pressure so that stresses in the soil are lower than the soil strength. Measurements of soil displacement and soil stress were made for a six-row sugarbeet harvester at two wheel loads, 81.6 kN and 111.3 kN. The tyre was a Trelleborg TWIN 800/60-38 at a tyre inflation pressure of 220 and 90 kPa for the lower load, and 220 and 140 kPa for the higher load. Wheeling was made at a water content close to field capacity. Soil displacement and vertical soil stress was measured at 30, 50 and 70 cm depth, and precompression stress was determined on soil from the same depths. Ground contact area of the tyre was measured on hard surface.

At the lower wheel load, soil stress and soil displacement at 30 cm depth was approximately double for 220 compared to 90 kPa inflation pressure, changes were statistically significant. There was a tendency of lower stress for low inflation pressure at 50 cm depth, while no differences could be seen at 70 cm depth. Stresses at 50 and 70 cm depth was higher for 111.3 compared to 81.6 kN wheel load. The measured contact area correlated well with the tyre inflation pressure. The measured soil stresses correlated reasonably well with calculations of stress distribution in the soil. Soil displacement occurred at 50 and 70 cm depth despite the precompression stress was higher than the measured soil stress.

The results show that for a given tyre, reducing tyre inflation pressure may have a large influence on compaction in the upper part of the subsoil, while effects deeper in the subsoil are small.

Key words: subsoil compaction, sugarbeet harvester, soil stress, soil displacement, tyre inflation pressure

Soil mechanical parameters derived from the CA-database "subsoil compaction"

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Abstract

A database dealing with results of field and laboratory experiments on the impact of subsoil compaction on physical, mechanical and crop parameters is being developed within the concerted action (CA) project "Experiences with the impact of subsoil compaction on soil, crop growth and environment and ways to prevent subsoil compaction". The database at the moment accumulates 312 Excel workbooks.
On the basis of the database the precompression stress and the shear strength parameters cohesion and angle of the internal friction were calculated for the German workbooks (133 workbooks with more than 300 horizons) in order to assess the trafficability of agricultural soils. The calculation was made for the texture groups sand, silt, loam and clay at different water suctions (pF 1.8 and 2.5) and 5 soil structure classes for the top- and subsoils.
The soil texture group sand shows the highest precompression stresses at both water suctions in the topsoil as well as in the subsoil. With increasing amount of clay the mechanical stability decreases. All soil texture groups show clear differences between top- and subsoil (rel. precompression stress of the topsoil: S: 57-64%, U: 50-51%, L: 43-50%, T: 29-44%).
A decrease of the water suction reduces the stability in the topsoil to 56-79% and to 74-88% in the subsoil. Sands react less sensitive than other soil textures towards a change in water suctions with a decrease of only 21% in the topsoil and 12% in the subsoil. No or minor aggregated horizons (single-grain, coherent, prismatic) are less stable than stronger aggregated horizons (subangular, blocky).
A decrease of the water suction reduces the cohesion to 62-85% in the topsoil and 74-82% in the subsoil. Sands show higher cohesion values in the topsoil than in the subsoil in contrast to the other soil texture groups. The angle of the internal friction decrases with increasing clay content independent of the water suction. A higher aggregation leads to an increase of the shear parameters.
The determination of the grade of aggregation of soil textures seems to be the key factor in order to assess the mechanical strength of a soil.

Key words: precompression stress, cohesion, angle of the internal friction, database

Stress distribution under a tracked vehicle

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Abstract

In order to lower the risk for compaction, pressure at the soil surface should be as small as possible. One possibility to lower soil contact pressure is to increase contact area by using tracks instead of wheels.

The pressure distribution beneath a tracked vehicle was studied at two different sites in Denmark in the autumn 2000. At the same time, pressure distribution under a wheel tractor was measured and used for comparison. In order to have real tillage conditions, all the investigations were done while ploughing. The ploughing was onland for the tracked vehicle, and both onland and conventional for the wheel tractor.

Soil vertical displacement and vertical stress were measured at different depths in order to gain information on pressure transmission. Additionally, vertical stress distribution perpendicular to the driving direction was measured in the topsoil layer. Soil strength (preconsolidation stress, cohesion, and angle of internal friction) was determined in the laboratory.

Comparison of the tracked vehicle with the wheel tractor showed that measured maximum vertical stress at 10 cm soil depth was smaller under the tracked vehicle than under the onland ploughing wheel tractor. At 30 cm soil depth, however, measured maximum vertical stress was about the same under the tracked vehicle and the wheel tractor ploughing onland, but half as high than under the wheel tractor ploughing conventionally.

The measurements show that contact pressure at the track-soil interface is only low if the load is evenly distributed. This is normally not the case when using standard adjustment of tillage tools. It is therefore of high importance to balance a tracked vehicle by adjusting the tillage tool and the tractor to each other (e.g. by optimising the position of the pulling point of the tillage tool) in order to reach an even pressure distribution under the track resulting in small maximum vertical stresses.

The procedure of adjusting tillage tool and tractor seems to be a high, unused potential in order to prevent compaction.

Key words: tracked vehicle, stress distribution, soil stress

Soil cover structure, subsoil compaction and matter movement in landscape

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Abstract

Introduction. Soil cover is not uniform formation, but very complex, space variable soil mosaic. The origins of this variability are different: variability of parent material, paleorelief, intensity of natural and antropogenic soil process, etc. The processes of soil and subsoil compaction formations are also variable in space. Respectively, specific processes of water and matter movement in landscape are transformed according the zones of soil compaction. The aim of this investigation is to investigate the regularity of soil cover structure, formation of compacted layers and the changes in soil processes of matter movement ("preferential flow" formation).

Materials and methods. Spatial distribution of soil horizons and physical properties were investigated on soil transects of length 40-46 m and 1.5 m depth.. The transects located on agricultural field in tempered zone of north-east of Russia (Vladimir region, Russia). The soil properties were determined in arable, subarable and subsoil layers with the horizontal step of 25 cm (160-184 samples on each depth of investigation). On length of this transect 5 soil different types were chosen, in which subsoil compaction was appreciably expressed, and also part of objects, where the compaction was not marked or it was marked poorly. The method of starched label was used for investigating the movement of a moisture and substances in a soil cover in places where the compacted zones were presented.

Results and discussion. In case of a complex soil cover the compact subarable layer is not formed as layer but as separate parts, «lenses». The investigation of matter movement in this specific zones of soil cover shows that the formation of the separate "water ways" around this condensed lenses on depth 35-55 cm attracts considerable attention. This "water ways", "fingers" are kept up to sufficient depth. Subsoil compacted layer results to concentrate the water flows, wetting front instability and forms special wetting ways, so called "preferential flow path" or "fingers", filtrated through this compacted zones to the deep layers. This investigations show the role of subsoil compacted layers to concentrate soil water flows, to form preferential flow path in soil profile and emphasize the impact of subsoil compaction space distribution on matter movement in landscapes and on environment.

Key words: soil cover, compaction, "preferential flow".

Response of clay soil macroporosity to stress caused by tracked tractors

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Abstract

The stress transmitted to soil by a light and a heavy tracked tractor and the effects of stress on soil macroporosity were examined in a field experiment on a clay soil. The objective of the study was to quantify the vertical normal stress transmitted to soil by tracked tractors and the changes in the macroporosity of soil caused by the stress.
The field experiment was carried out on clay soil which had 0.7 and 0.8 g clay (0.002 mm) g^{-1} in the topsoil (0-0.2 m) and subsoil (0.2-0.5 m), respectively. The three treatments were: (A) medium size wheel tractor (weight 4.5 Mg, tyre inflation pressure front 120 kPa rear 130 kPa); (B) light, unmanned tractor (2.5 Mg, track width 0.32 m and length 2 m); (C) heavy tractor (12.5 Mg, 0.83 m, 2.51 m). There were four replicates of each treatment.
Pressure transducers were installed beneath the centre of the rut of the wheel/track at the depths of 0.2 and 0.3 m with great care to avoid disturbing the structured soil. Stresses were measured during five repeated passes along the same rut. During the measurements, mean soil moisture content in the 0-0.30 m layer was below field capacity. After five passes, undisturbed soil samples (diameter 0.15 m, length 0.55 m) were taken from the centre of the rut. In the laboratory, the samples were cut into three subsamples: a plough layer, a middle layer and a bottom layer. The saturated hydraulic conductivity and the macroporosity (diameter > 0.3 and 0.03 mm) of subsamples were determined. Likewise, the number of earthworm burrows (cylindrical pores > 2 mm) were counted from the bottom of subsamples (at 0.2, 0.25 and 0.55 m depths). In the presentation, the results of stress and macroporosity determinations will be discussed.

Key words: soil structure, wheel/track load, topsoil, subsoil

Effects of heavy harvesting machines on soil structure

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Abstract

On the one hand physical protection of soils, especially the prevention of structural damages, is an important goal of sustainable agriculture. On the other hand current economical conditions for agricultural production and the development of vehicle technology favour the use of big heavy machinery with high mobility even under bad soil conditions.
In order to get information about the potential risk for soil compaction resulting from these developments, field traffic experiments with heavy vehicles have been carried out in six consecutive years on different sites in the north-eastern part of Switzerland.
The most important questions were:

- Are there differences between smaller and bigger vehicles in its effects on soil structure, especially in the subsoil, and what are main soil and machinery properties contributing to the compaction risk?
- Which parameters are suitable to assess changes in soil structure caused by the compaction process (or better: the process of structural deformation) and can these changes be simulated by models?

The experiments were carried out in sugar beet fields during harvest campaigns in late autumn. Soils differed in texture, structure and type, soil water potential during wheeling was normally less than pF 1.8. Sugar beet harvesters differed in type (hauled, self-propelled), wheel geometry, wheel load and tyre equipment.
Measurements took place under the centre of the harvester-tracks, using both in situ measurements (stress distribution in the soil, penetration resistance, infiltration) and soil sampling/laboratory analysis (bulk density, porosity, pore geometry, preconsolidation stress, angle of internal friction, cohesion) at soil depths of 20, 40 and 60 cm.
Symptoms of typical soil compaction processes were evident in the topsoil at 20 cm depth and normally more intense under the tracks of heavier vehicles. Stress decline with depth was often unexpectedly high, therefore at 40 cm depth only rarely typical changes of structural soil parameters could be detected. Nevertheless under certain constellations of soil conditions and contact area properties interesting reactions of soil structure occurred. At 60 cm depth however no structural changes were measurable.
Measurements of soil mechanical properties showed changes caused by field traffic similar to that of structural parameters.
Horizontal stress distribution underneath tyre tracks was very uneven in the upper 10 cm of a sandbed. At 30 cm however stress pattern had changed completely and could be simulated reasonably well by a FE-model. Another FE-model with a different constitutive law was capable to simulate soil displacement under tyre tracks satisfactory.

Key words: Soil structure, field traffic, macroporosity, soil mechanical properties, FE-model

Influence of different harvesting methods in the Black Forest on the habitat ecology from a soil physical point of view

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Abstract

The estimation of consequences of mechanized harvesting procedures during the transformation from pure spruce stands to close-to-nature mixed forest stands in the southern Black Forest is one part of the BMBF project "Future orientated Forest Management".
The use of heavy harvesting ("Königstiger") and transport vehicles on *Braunerden (Cambisols)* and other forest soils in the *High Black Forest Region* indicates strong soil stresses and soil displacements. These aspects are obtained in a high resolution by the use of SST (Stress State Transducer) and DTS (Displacement Transducer System) systems. Complete harvesting processes with total lengths of 10 minutes were observed with a resolution of 50 units per second.
For the determination of the soil mechanical parameters like cohesion, angle of the interior friction and precompaction as well as the important plant ecological aspects: bulk density, pore space and pore size distribution, saturated water conductivity and air conductivity undisturbed soil samples were taken. After saturation the samples rings with a volume of 236 cm^3 were drained to a water tension of –60 hPa and the precompression was determinated by using the oedometer test. Two procedures were taken, the "Standard Soil Compression Test" and the "Multi Step Soil Compression Test". The shear parameters were determined with a box shear test.
The induced soil stresses caused by harvesting were in general lower than those under comparable tillage soils. These effects are caused by the stabilization of the soil structure by the dense root system. The maximum soil stresses were higher than the mechanical stability of the soils. Therefore the stresses caused sustainable impact on the soil habitat ecology (air permeability...). The degradation of the soil structure caused by stresses higher than the precompression had effects on the pore continuity and lead to blocked porosities.

Effects of increasing compaction levels on the efficiency of nitrogen topdressing of grasses

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Abstract

Trampling by livestock and machinery traffic on hill land pastures may degradate the structure of the soil and restrict the efficiency of swards fertilisation.
An experiment was carried out on hillside soil (50% clay) in order to determine compactness levels compatible with regular use of nitrogen topdressing of pasture grasses.
Four plots, the control (C) and those submitted to dynamic compaction once (C_1), twice (C_2), three times (C_3) were seeded with *Lolium perenne and Phleum pratense*. At the Spring and Autumn regrowths, the grasses were topdressed with 40 $kgNha^{-1}$. The following were assessed: each year: a number of soil chemical properties, bulk density, penetration resistance down to a depth of 300 mm, cumulative water infiltration and, on undisturbed cores, the hydrological properties.
During controlled regrowths, soil temperature and water content changes were monitored; samples were taken in two layers down to 200 mm at eight nightly intervals for measurement of N and $N0_3$ concentrations. At harvest, total dry matter yields and, on randomly selected plants, the leaf areas were measured. The content of crude fiber, total N and $N0_3$ was determined on the herbage.
Dry bulk density was significantly higher in the upper layer of the more compacted plots C_2, C_3. Conversely the water content at saturation and at field capacity was considerably reduced in the surface layer. Cumulative water infiltration in the control was 20%, 65% and 80% higher compared with C_1, C_2, C_3.
At all sampling dates the content of total N in the two soil layers was the hightest in the control; a trend towards higher nitrate concentrations was found in the surface layer of C_2, C_3.
Herbage yields were 30%, 40% lower in C_2, C_3 compared with the control plot; leaf areas were also significantly smaller. The herbage from C, C_1 plots showed the highest content of protein and the lowest of crude fibre.
The effects of compaction were limited to the top soil, and considerably affected the N uptake of the deepest layers of the plots having highest compactness. This behaviour suggests the formation of a superficial pan, thicker in the soils submitted to repeated compaction.

Key words: sloping pastures, soil compaction, N fertilization

Soil compaction evaluation on an irrigated rotation short-duration grazing system

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Abstract

Reduction in pastures productivity has been attributed to the deterioration of soil quality. Soil compaction by animals trampling is one of the factors responsible for the degradation of the physical quality of soils under pastures. The objective of this research was to evaluate soil compaction on pastures using soil resistance to penetration measurements. The research was conducted at the experimental farm at ESALQ/USP on an established irrigated rotation, short-duration grazing system. Simultaneous measurements of soil resistance to penetration and soil moisture content were obtained in plots with three post-grazing residue levels (1000, 2500 and 4000 kg MS ha^{-1}). The influence of soil water content on the soil resistance to penetration was taken into account using regression analysis techniques. After this procedure the results indicated that soil resistance to penetration values were significantly higher in the treatment with the smallest amount of post-grazing residue. Moreover the other two treatments had no significant difference with respect to soil resistance to penetration.

Influence of soil water content profile on compaction

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Abstract

A previous study* showed that a slight topsoil drying prior to wheeling should modify stress propagation so that it prevents excess compaction. In order to investigate the influence of soil water content profile on soil compactibility, two experiments were conducted on a loamy soil. First, wheeling tests were operated at 5.5t load on a plough layer at w=23%. By adding a drier layer (w=3%) of 5cm width, we studied the impact of a drier topsoil on compaction. Soil bulk density and rut depth were determined after wheeling. Secondly, a shrinkage plate apparatus of 25 cm diameter was used to apply a constant stress of 1 bar on soil. This load was similar to that exerted by tractor tires. Two soil water status were studied : a topsoil layer considered as homogeneous water content (w=22%) and a tilled layer consiting of an air dried layer (7cm) overlaying a layer at w=22%. The compaction process were examined at seven location in cultivated plot. Soil bulk density and settlement were measured after loading. Both experiments show that a drier topsoil layer changes soil compactibility over a depth of 5 cm, in contrary to previous study*, it does not concern all the plough layer.

*Guérif, J. 1984. The influence of Water content gradient and structured anisotropy on soil compressibility. J. Agric. Engng. Res. 29 : 367-374.

Relationship between soil compaction and soil erodibility

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Abstract

The rate of soil degradation is greatly accentuated by using land for whatever purposes it is not capable of and by unsuitable methods of soil and crop management. The world is now loosing some billions of tons of topsoil per year. In order to sustain our most valuable, non-renewable resource we need thousands of erosion researches even for building the most basic database.
In Hungary, during the last decade there were rainfall simulation studies. We measured all important basic soil data. In the present article we wish to analyze how soil compaction effects runoff and soil loss.
Our rainfall simulator equipment was Pannon R-02 type. We used VEE-JET 80100 sprinkler heads that are the standards in the US. The diameter of nozzle was 6,4 mm. The velocity of raindrops were 7,2 m/s. The intensities were 30-40-60-90-130 mm per hour. We measured runoff and soil loss during our rainfall simulation.
The rainfall simulations were done on fallow plots that were handled the same way for two years in order to remove plant residues as well as possible according to USLE description of Wischmeier and Smith.
Our purpose was to compare the soil loss data under different compaction circumstances. We used soil loss in grams per square meter time minutes for comparison. Description of state of soil compaction was done with field measurements of soil resilience and soil moisture content in per cent of dry soil.
The results showed that in the given circumstances, among different soil types in Hungary and with rainfall simulator, soil erodibility was rather connected to other soil characteristics than to soil compaction.

Key words: soil erodibility, rainfall simulation, soil compaction

Oats growth and yield as affected by reduced tillage and light tractor traffic

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Abstract

Through soil compaction, wheel traffic markedly affects the structure of agricultural soils and reduces crop production. Excessive soil compaction is also a major obstacle to the adoption of conservation tillage practices, which often are advantageous in respect of erosion control. In the recent decades, the worldwide increase in the weight of farm machinery has increased the likelihood of progressive subsoil compaction, which is long-lasting and difficult to correct. The effects of topsoil and subsoil compaction can be controlled by using low-weight farm machines with low ground contact stress. Modulaire Ltd. has developed a light, unmanned tractor for agricultural applications. In the present study, a field experiment was carried out at the Agricultural Research Centre of Finland (MTT) with the following objective: to investigate the functioning of a soil-plant system in ploughless tillage, when tillage and sowing operations are made with light tractor. The preliminary findings regarding crop growing and crop yields in the fourth to sixth experimental years are discussed.

The field experiment was commenced on a clay soil in 1995. Six year experiment was laid out in a split-plot design with four replicates. The main plot was autumn tillage: (P) ploughing to 0.23 m depth, and (C) stubble cultivation to 0.12 m depth. The subplot treatment was tillage and sowing operations done with: (S) a medium-size, conventional tractor (weight 4-5 Mg, tyre inflation pressure 80-100 kPa), and (M) a light, unmanned tractor (2.5 Mg, rubber tracks 2000 mm length, 320 mm width). Spring barley war grown in 1995 and oats in 1996-2000. In 1998 to 2000, leaf area index and height of crop and the development stage of plants were determined weekly during the growing season. Root density during two leaves stage and flowering was calculated at 0.15, 0.30 and 0.50 m depths. Likewise, grain yield and nitrogen yield harvested in grain yield were measured.

The growing season in 1998 differed from that in 1999 clearly. The total precipitation in June and July was 40% higher in 1998 and 40% less in 1999 than average. In 2000, the beginning of growing season was dry but later the precipitation was nearby average. In 1998, soil wetness hindered crop growth more in the stubble cultivated plots than in ploughed plots. Stubble cultivation and the use of medium size tractor reduced the nitrogen yield by 15 and 14%, respectively. In 1999 and 2000, ploughed topsoil (0-0.15 m) was clearly dryer on sowing day than stubble cultivated topsoil. Oats sprouted faster and better in stubble cultivated soil, and the crop was scanty in ploughed plots during growing period. In each year, the crop growth was very sensitive to the soil and weather conditions immediately after sowing.

Key words: LAI, root growth, seed yield, nitrogen yield

Soil compaction problems in Slovakia

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Abstract

Soil compaction problems are important not only from agricultural point of view but they are important and risky for the environment as a whole. Soil compaction influences all components of environment through acceleration of the other processes, e.g. soil erosion, rivers pollution by fertilisers, etc. and not only the soil. From this point of view it is the global problem.

Soils with different properties according to textural category and morphological unit react differently on soil compaction processes. The most fertile soils in our country conditions are medium heavy loamy soils without horizon of significant clay cumulation i.e. Chernozem, Fluvi-haplic Phaeozem, Orthic Luvisol.

Heavy - clayey soils as well as soils with horizon of significant clay cumulation- argillic horizon tend directly to compaction. This type of compaction resulted directly from soil conditions is called primary compaction and such soils are cultivated with difficulties. The most relevant problem in this case is suitable soil moisture content which must be in interval between field capacity and point of decreased water availability in whole profile during cultivation or harvesting. This moisture interval is very important in prevention of additional compaction.

Coarse and medium textured soils without argillic horizon in their profile are not compacted primarily. In conditions of intensive agricultural utilisation they are often compacted due to human activity. We indicate this type of compaction as secondary - man made.

Secondary compaction is one of the most significant factors bringing down soil fertility in our country, because of its spreading on our most fertile but very intensively exploited soils. Unfavourable soil physical conditions are characteristic mostly for arable soils, vineyards are less compacted and the best conditions from soil compaction point of view have meadows.

In conditions of intensive agricultural soils utilisation, clayey soils and soils with argillic horizon are often compacted primarily as well as secondary. Such type of compaction - combined compaction is the most widen type of compaction in our country.

Slovakia has accepted Recommendation European Committee (EC) on European strategy in environmental conservation (1990). We have permanent monitoring of all the environmental components. The monitoring respects also many other international documents, recommendations, or even directions.

Concerning the obtained data it may be said that the most evaluated soil physical properties have been changed for the worse especially on Chernozems and Luvisols - the most cultivated soils with heavy machinery - opposite to Cambisols and the other soils.

Sandy soils are texturally the most resistant to compaction. On the other hand the loamy soils have the remarkable susceptibility to compaction. Finally, the clayey soils are often compacted naturally and they are called „minute soils" because of very short time in which their moisture content allowes cultivation without soil properties injury.

Key words: primarily soil compaction, secondary soil compaction, soil morphological units, soil texture, inclination to compaction, soil monitoring

Influence of low weight traffic under different management systems on some physical soil properties in a high-density apple orchard

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Abstract

During the 1982-1999 period investigations on the effects of the controlled mechanical traffic performed both at one single moment and in time on some physical soil properties were done. The experiment was conducted in a high-density apple orchard. The technological traffic was performed by help of a 2.2 Mg total weight tractor. Soil resistance to penetration (RP) down to the 50-60 cm depth increased as the number of passes grew up. There was a higher increase in RP within the mowed sod strips or mulch versus the cultivated or herbicide treatments. The controlled mechanical traffic performed 5-10 times per year during the 1982-1987 period did not determine a clear increasing trend in the compaction degree due to time attenuation of the compaction effects made by the freezing – thawing process. Soil compaction attributed to the technological traffic was noted on the studied depth (0-30 cm) even 12 years from the end of experiment.

Key words: bulk density, soil compaction

Influence of long-term cultivation on soil physical properties and compaction of an umbric horizon

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Abstract

Physical characteristics of soils with a high organic matter content, as for example virgin forest and meadow soils, are generally better than those of their cultivated counterparts. Soil samples were collected from the topsoil of both, an arable field, cultivated at least for over 50 years, and an adjacent meadow plot. Samples exhibit similar texture characteristics and contrasting organic matter (OM) contents (4.8 % and 6.5 % for the cultivated and the meadow soil, respectively). Selected physical properties were determined on aggregates obtained by sieving air-dried samples between 2 and 3 mm. The performed physical tests included water retention curves, shrinkage curves and mercury intrusion porosimetry. In addition, compaction tests by means of an oedometric cell were made. Water characteristics were determined using a Richard apparatus. Shrinkage curves were obtained from bulk density measurements of 2-3 mm aggregates by hydrostatic weighing in kerosene. The pore size distribution from about 4 to 10^6 nm pore radii was measured by mercury intrusion porosimetry. Compaction of aggregates into cylindrical cores was achieved using an oedometric cell, 7 cm in diameter and 2.4 mm high. Two different loads, 100 and 400 kPa were used to compact aggregate beds with different water contents into the oedometric cell. Packing density for each applied load and water content of the cylindrical cores was characterized in terms of structural void ratio, i. e,. interaggregate void ratio. This way, confined compression curves relating vertical stress and structural void ratios were obtained. Strong differences between saturated water contents of the two treatments were appreciated; however there was no visible effect of organic matter content beyond 1.500 kPa water potential. Total porosity in the range 100-0.006 mm diameter was significantly higher for the meadow soil than for the cultivated soil. However increased O.M. content did not modify the pore volume of the smallest sizes, below 1 □m diameter. The low shrinkage potential of the studied soil, due to the caolinitic nature of the clay fraction was also verified. O. M. content modified shrinkage limits, but not shrinkage potential. For a given water potential and applied vertical stress with the oedometer cell, the structural void ratio was higher (i.e. lower packing density) for the soil with higher organic matter content. In conclusion, for the studied soil and climatic conditions, the O.M. content in the topsoil do modifies their major physical properties and mechanical behavior, protecting soil against compaction.

Key words: porosity, shrinkage, compaction, oedometer, organic matter.

Development of a hydraulic driven soil penetrometer for measuring soil compaction in field conditions

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Abstract

The soil compaction sometimes becomes an important physical limiting factors for the root emergence and the growth of plants. Therefore, it is essential to control soil compaction that is normally caused by heavy traffic on field during to the growing season. The soil compaction in field is usually measured by using a standard soil cone penetrometers which can be different several type due to their design. For common applications, standard hand penetrometers such as delmi and bush types are used, and the soil compaction is presented as cone index which is the force acting on device handle divided by standard cone base area during to the penetration of penetrometer cone for the constant penetration rate. Most of the time, especially, in heavy soil conditions, measuring the soil compaction with a standard hand penetrometer produces measurement errors if the cone of penetrometer can not be pushed in to the soil with standard rate. Obtaining data is also difficult and takes long time and effort with hand penetrometers. For this reason, a three hitch mounted and hydraulic driven soil cone penetrometer has been designed in order to reduce time and effort and to reduce possible measurement errors for the sampling of soil compaction data for research purposes. The hydraulic penetrometer, is mounted on three hitch points and an hydraulic piston pushes standard penetrometer cone in to the soil in constant speed. Forces acting on cone base is recorded with a computer based 16 bit data acquisition system that is composed on a load cell, a portable computer, signal amplificatior and a necessary control software for the sampling. The maximum load cell capacity in linear region is 500 kg that corresponds 10 MPa. An A/D converters card provides 10 V direct current to excite the load cell that is an actually bridge circuit. It's minimum measurement interval is 0.038 kg per mV for the calibration. The system also includes a soil depth sensor that is made as turning electronic potantiometer placed on an hydraulic cylinder. The rotation of the potentiometer is sensed as a linear movement in 0.11° per mm length as the depth sensor calibration. The constant penetration rate of the soil penetrometer cone is 30 mm/s, and this speed is provided by a control valve that has maximum oil pressure with an 1.54 L/min oil flow.

Deriving threshold values for soil compaction from expert judgement

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Abstract

Many European countries have enacted their soil protection legislation. However, the execution of this legislation lacks of rules to assess soil health and to decide on sustainable management practices in many aspects. There is a particular lack of criteria and threshold values to assess the state and risk of soil compaction. In the recent past, much effort has been made in sophisticated experiments to describe the processes and effects of soil compaction. However, the specific results of single experiments cannot be applied to any other case in a general way. On the other side, different kinds of experts (scientists, officers, farmers) dispose of personal experience that allows them to judge soil compaction and the feasibility of the experimental data within their working fields.

This contribution presents an ongoing elicitation of expert judgement to derive meaningful and operable criteria and threshold values for the assessment of soil compaction. Experienced soil scientists described six different soil profiles in the field and, afterwards, judged their state and susceptibility of soil compaction by means of a questionnaire. In a closing workshop, the experts agreed on final rankings of the soil profiles.

Parallelly, the physical soil properties of the test profiles were analyzed in the laboratory. The experts' groupings are compared to statistical grouping of the laboratory data with cluster and discriminance analysis. The results will be ready to present at the conference.

Key words: Expert judgement, soil compaction, decision making

Session: *Soil Structure*

The soil structure component of soil quality under alternate grazing management strategies

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Abstract

The concept of soil quality has received considerable interest as a measure of the environmental impact of agriculture. Such measures are increasingly important as agriculturalists (and their customers) move to include depreciation of natural capital in the assessment of farm performance. As a concept, soil quality has numerous advantages, but its application has several potential disadvantages. In particular, soil quality criteria are site specific and relate to the particular purpose of a user, unlike the criteria used to assess air and water quality. This paper evaluates the concept of soil quality, and recent criticism. It is argued that soil quality criteria are useful, provided the context is clear, the indicators used are relevant, and the methods used to measure them are appropriate.

Soil structure is considered an important component of soil quality. The tablelands of south eastern Australia, where grazing of livestock is the dominant land use, are a significant source of surface water and groundwater supplies for a large part of the continent. Degrading soil structure will alter the relationship between infiltration and runoff, thereby impacting on soil erosion, pasture production, and catchment health.

Changes in soil structure may be induced by soil management. In an environment characterised by seasonal weather extremes, grazing methods which extend the period of active pasture cover are likely to extend the duration of root growth and development, increase the gross amount of organic matter available to the soil and soil biota, contribute to long term improvement in soil structure, and reduce soil erosion. The deleterious effects of livestock traffic on soil structure, particularly compaction, are well documented. It has been suggested that the impact of livestock could be minimised by using high intensity short duration (HISD) grazing management. Although livestock impact is still present, HISD grazing events are separated by long periods of rest, allowing for pasture recovery, beneficial changes to pasture species composition and potential improvement in soil structure.

A long term replicated experiment has been established at The University of Sydney, Orange, to determine the most appropriate tools to quantify changes in soil structure under alternate grazing systems, including HISD. A number of soil properties relating to soil structure are under investigation, including soil hydraulic conductivity, image analysis of pore geometry, penetration resistance and soil microbial activity, as well as conventional measurements of bulk density and organic carbon. These methods are discussed, and results from the first year are reported. These measurements will enable soil structure change to be incorporated into grazing management decision models.

Key words: Soil quality, soil structure, grazing strategies

Soil structure quantification approaches for 2-domain models

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Abstract

In structured soils, water and solute movement through continuous macropores, such as root and worm channels or the inter-aggregate pore network, may be considerably faster than in the soil matrix. During transient unsaturated flow, local non-equilibrium conditions in pressure head and solute concentration may occur between preferential flow paths and matrix. A number of two- (and even multiple-) domain models have been proposed which consider flow and transport in two interacting pore continua separately. The empirical parameters of two-domain models characterise pore domain and mass transfer properties should inherently be related to soil structural properties. Currently, structure-related parameters have been obtained by fitting model results to experimental data rather than by direct measurements. This paper summarises attempts to independently determine such soil structure parameters of a dual-permeability flow and transport model for subsequent relation to data of soil protocols. A theoretical derivation of the dual-permeability water and solute mass transfer terms resulted in parameters describing the geometry (shape and size) and the hydraulic conductivity and diffusivity of soil matrix blocks as macroscopic parameters. The transfer term parameters have been evaluated for idealized geometries and compared with equivalent 2-dimensional models for simple geometries. For naturally structured soils with complex geometries, an extension was proposed based on the relation between surface area and volume of the matrix. From X-ray computed tomography data of undisturbed soil cores, surface areas, S, and volumes, V, of the matrix are calculated for different threshold bulk density values. Comparisons for two differently structured soils suggest the S/V-relations to be characteristic for particular structures. For a sensitivity analysis the soil structure related parameters have been roughly estimated from data of soil protocols. Mass transfer was more sensitive to a hydraulic and diffusive resistance possibly caused by clay-organic aggregate coatings than to geometric parameters. The hydraulic and diffusive transfer parameters were measured using sorption experiments. Intact aggregates compared to those where the coating was removed showed reduced water absorptions. Still, a number of problems remain especially with respect to the separation of the structured soil into 2 domains, for weakly-structured soils, and for swell-shrink soils.

Key words: soil structure, dual-permeability model, mass transfer, parameter estimation

The effects of grass-clover mixture and precipitation on organic matter content and aggregate stability in a loamy sand Spodosol.

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Abstract

A better understanding of the processes of water-stable aggregation should take into account the soil organic matter transformation affected by climatic conditions and management practices. Grass-clover mixtures are often used as the only source of organic matter for light-textured soils in the northwestern region of Russia. The objective of the present study was to evaluate the relationships between water-stable aggregation and organic matter content in a light-textured podzolic soil in a seven-course rotation at different precipitation. Disturbed field moist samples were taken one time a month from May to September of 1997-2000 from the 0-10 cm layers of plots established on a podzolic loamy sand soil classified as Spodosol according to FAO classification. The crop rotation included a grass- clover mixture, potato, spring barley, winter rye, winter wheat and winter rye with downy vetch. During the studied vegetation periods mean monthly air temperatures ranged from 7 to 19.5 oC. Total precipitation reached 566.3, 772.3, 443.5 and 861.7 mm during the vegetation periods in 1997, 1998, 1999 and 2000, respectively. Total organic matter content in the whole soil samples and in the water-stable aggregate-size fractions were determined by a wet combustion method. Measurements of aggregate-size distribution were carried out by a wet sieving with rotary sieves having sizes of 0.5, 1.0, 2.0, 3.0, 5.0 and 7.0 mm. Our data showed that at the growing of grass-clover mixture the organic matter contents in the whole soil samples and in the water-stable aggregate-size fractions were higher than those at the growing of cereals. Compared to the dry vegetation periods, the organic matter content only in the whole soil samples showed a trend to increase during the wet vegetation periods. However, the organic matter content in the loamy sand Spodosol began to rapidly decrease two years after the final harvesting of grass-clover mixture. A total amount of 0.5-7.0-mm water-stable aggregates was greater after establishment of the grass-clover mixture than after that of the cereals. This was probably due to a greater input of hydrophobic organic substances, derived from the grass and clover plants. At the growing of grass-clover mixture and other crops the total amount of 0.5-7.0-mm water-stable aggregates essentially decreased with decreasing organic matter content in 1999 with the lowest precipitation (443.5 mm). Even under the more favorable climatic conditions of 2000 the growing of grass-clover mixture and cereals only negligible contributed to an increase in organic matter content and to a self-recovery of water-stable aggregates during the whole vegetation period. Despite the favorable effects of grass-clover mixture (Phleum pratense and Trifolium pratense) on the organic matter and structural status of the loamy sand Spodosol, an additional incorporation of plant residues or organic fertilizers is needed to: (1) cover high losses of soil organic matter during the dry vegetation periods and (2) increase the water-stable aggregation as one of the key indicators of soil sustainability.

Key words: Organic matter, aggregation, grasses, precipitation

The effect of olive oil waste on physical properties of soils degraded due to excessive tillage

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Absract

Turkey is a Mediterranean country, producing olive oil. Vegetation water which is waste materyal of olive oil mills, is an important proplem for environment. In this study, the effect of vegatation water, which is very rich in organic matter, on physical properties of the soils low in clay content, degraded as a result of ongoing excessive tillage, was invastegated. Three replicated and three doses of liquid and solid forms of vegatation water was applied to two soil series for two years.

Soil samples were taken between the applications and after the experiment was completed. Soil samples were analyzed for soil properties,especially for those properties related to soil structural features, aggregation index, aggregation stability index, water permeability, plant available water content, total porosity, pore size distribution, pH, total soluble salt content,organic matter content, and Na, P, K, Ca and Mg contents. The results showed increases in soil organic matter content with increasing doses. These increases were greater under applications of solid forms. Soil Na contents, which adversely affect the formation and stability of soil structure, increased after applications of both forms. However, since the soils were sandy, the Na leached from the soils during winter and spring and did not accumulated at such high levels that could cause a proplem. Increases in total soluble salt contents were not significant. The amounts of cations such as K, Ca and Mg increased. The changes in soil Ph was not significant . The organic matter had the major effect on formation of soil structure. Organic matter slightly effected soil structural properties (aggregate stability, aggregation index, etc.). This effect was not statisticly important in the surface soils due to low clay content of the soils and rapid degredation of organic matter because of high temperature.

In conclusion, the both forms of application from vegatation water did not have any adverse effect on soils, except slight increases in Na contents of the soils. Although the positive effect of vegatation water on soil structural properties was not significant, its overall effect on soil properties is important. To prevent the environmental proplem caused by vegatation water and to benefit from its organic matter, from vegatation water safely be applied to soils of these two series.

Key words: olive oil waste, soil properties, vegatation water.

Effect of oil mill effluents on soil aggregation properties

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Abstract

This study evaluates the efficiency of waste by-products of olive oil extraction as a soil conditioner. Because of their adhesive, hydrophobic, and fertility properties, olive mill effluents are supposed to improve soil aggregation and to change the associated soil characteristics (bulk density and conductivity).
In southern Italy, over a period of three years, soil physical properties were measured on three sites (olive plantation, cherry orchard and durum wheat fields), near surface and below surface in order to detect changes in soil physical characteristics when olive oil effluents are added to the soil. On the same time, soil properties were monitored also in the untreated soils. The soil of the olive plantation (loam, according the USDA classification) is more light, due to the abundance in sand and in silt, while the cherry soil (clay) could be considered as an heavy soil. The wheat soil is a clay loam soil, between the cherry orchard and the olive field. The aggregate mean diameter was determined by sieving a representative quantity of soil sampled from two layers (0-20 and 20-40 cm in depth). Bulk density was determined by the "excavation" method which consists in drilling an hole at soil surface and replacing the volume of soil with sand having a known specific weight. The disk infiltrometer was used to determine un-satured hydraulic soil conductivity.
The introduction of mill effluents tends to increase the average diameter of aggregates, only in the upper layer between the soil surface and 20 cm in depth. These improvements were observed in clay-loam and in the loam soils, while in the clay soil the aggregate distribution does not change when mill effluents are incorporated into the soil.
Soil density and hydraulic soil conductivity are sensitive to incorporation of the olive waste into the soil. After a period of two years, the treated soils significanlty differ from the untreated ones, in that soil bulk density decreases and soil conductivity is speeded up.

Key words: soil conditioner, mill effluents, aggregate diameter, soils bulk density, un-satured hydraulic soil conductivity.

Areal porosity and water infiltration as affected by tillage methods

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Abstract

Areal porosity and pore-size distribution pattern significantly alter many soil properties affecting water infiltration. The porosity is largely influenced by tillage practices. The objective of this study was to relate total areal and stained porosity under different tillage practices to water infiltration.
An experiment (over 18 years) was conducted on a medium alluvial soil (50% silt +clay, 2.3 % organic matter). Four tillage methods were compared: I – loosening to about 20 cm; II – loosening to alternate depth (every 6 years to 20 cm and in the remaining years to 5 cm); III – shallow loosening to 5 cm each year; IV – sowing to the uncultivated soil (no-till). Areal porosity of all pores (> 0.2 mm) was determined on the opaque sections of soil blocks (8x9x2 cm). To analyse the stained (water-conducting pores), soil cores were taken in cylinders of length 20 cm and diameter 21.5 cm from the plots on which methylene blue solution was applied.
The tillage practices considerably influenced porosity and infiltration. We obtained the highest areal porosity of all and stained pores in I and the lowest in III. The relative differences in stained porosity between the treatments were more pronounced in the 10-20 cm than in 0-10 cm layer. The stained porosity decreased with depth, to the highest extent in III and IV. The highest infiltration rate was under I and considerably lower in the remaining treatments.

Key words: alluvial soil, tillage practices, stained porosity, infiltration

Deformation and stability of biogenic macropores under mechanical load by means of 3-dimensional computed tomography

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Abstract

The coarse pore volume, especially biogenic macropores are of vital importance for ecological soil functions like drainage and soil aeration. Heavy machinery i.e. high ground pressures may alter soil structure and morphology of coarse pores considerably. The stability of the pore system intercorrelates with moisture and applied load. Investigations of soil samples from a comprehensive field trail (32 different scenarios by load and moisture on a humous, silty loam) by means of 3D computed tomography revealed the mode and development of pore deformation, which are shown by animated video sequeneces.

The results of quantitative pore measurements like shape, minimum, mean and maximum of pore cross areas, lenght, volume and orientation in dependence from load and moisture are given.

The biogenic macropores investigated are ondulating structures with a mean spacing between minimum or maximum intersections of about 6 mm. Minimum and maximum cross sectional areas are strictly correlated with the mean cross sectional area of the pore. In case of mechanical load and subsequent deformation the pores keep their almost perfectly round shape despite the degree of deformation. Deformation starts with an increase in numbers of bottle necks and continuous decrease in the minimum cross sectional area caused by dislocation of intact aggregates into the pore space, while the maximum cross areas remain. These pores show a prominent inner roughness in their walls and the matrix stability is exceeded. Increasing load coupled with higher water contents leads to „plastic" deformation. Both minimum and maximum cross sectional areas and number of bottle necks decrease hand in hand with the length of open pores. The morphology of the latter becomes more smooth comparable to the original shape, although on a significant lower level in size. Aggregate stability is exceeded in these cases.

The different deformation stages from „stable" up to „plastic deformation" can be attributed to ground pressure and moisture classes. Up to a 31 Vol.-% moisture level, which is equal to the plastic limit, the soil matrix and pores remain stable from 80 to 118 kPa ground pressure. Passing a transition field at 129 kPa signifcant deformation appears at 141 kPa. Within the plasticity range auf 31 to 45 Vol.-% stability is already exceeded at 93 kPa with extrem deformation at 129 kPa and above. At moisture levels above the liquid limit (approx. 45 Vol.-%) the transition from „stable" to „deformed" is passed at 83 kPa with the transition from „deformed" to „extremely deformed" at 118 kPa.

Key words: pore stability, pore deformation, computed tomography, soil compaction

Soil compaction effects on structure and porosity of grey forest soil

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Abstract

The objective of investigation was to determine effect of compaction by agricultural machinery on changes of soil physical properties. Field experiment was conducted in Vladimirskoe Opol'e on Grey Forest soil. Dry (0.3-0.4 FC) and wetted (0.6-0.7 FC) sites were compacted by 1 and 3 passes of tractor T-150K. Soil physical properties have been measured in two trenches at wetted and dry sites perpendicular to the tracks at the depths 0-40 cm with increment 5 cm. The investigated properties were: bulk density, water content, soil structure. Soil samples for measurement of particle density and aggregate porosity in laboratory conditions have been also picked out under and between tracks. The goal of laboratory experiments was estimation of traffic effect on total and aggregate porosity at different soil horizons. The shrinkage characteristics of aggregates 3-5 mm, 5-7 mm and 7-10 mm were measured by hydrostatic weighing in kerosene within water content diapason from saturation to air dry.

Studies of soil compaction of Grey Forest soil showed:

1. The soil structure changed significantly at upper soil horizons in wetted plot. Percentage of aggregates fraction 7-10 increased more then twice as compare with control at layer 0-5 cm. This tendency is down with the depth and vanish at 20 cm depth. In dry plot no changes of structure were observed.
2. Main alterations of total porosity took place at plough horizon in wetted site. Decreasing of total porosity due to compaction below 20 cm was not significant. Opposite to wetted plot in dry one changes of total porosity were more uniform with the depth and zone of compaction was 10-15 cm deeper.
3. Data of the aggregate shrinkage characteristics testify difference between the degree of intra- aggregate porosity changes in dry and wetted plots. Most considerable reduction of the porosity occurred in aggregates fraction 10-7 mm and 7-5 mm in upper part of the soil profile in wetted site, whereas the in dry site compaction effected on aggregates fraction 10-7 mm in lower part of arable and upper part of subarable soil layer.

The analysis of total and aggregates porosity data leads to conclusion, that traffic of hard agricultural machinery causes significant reduction both of inter- and intraaggregate porosity of arable and subarable horizons of Grey Forest soil.

Key words: compaction, soil structure, aggregate porosity, Grey Forest soil.

Soil pore geometry in crusts developed under different irrigation regimes

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Abstract

In the Mediterranean environment, irrigation is the most widespread available technique to guarantee good level of crop production. The continuous application of such irrigation practices affect very much the soil pore geometry and in certain cases can bring to relevant soil structure degradation processes.
This paper aims to produce data concerning the change of soil pore geometry as consequence of different irrigation techniques; in order to detect such change morphological image analysis techniques were employed on undisturbed soil samples of an alluvial soil with vertic features.
Two different irrigation practices (furrow infiltration and sprinkler irrigation) on two different soil status (with eggplant crop and without crop) were tested. Each irrigation was applied on two trials in which, one refers to soil covered by crop (eggplant) and the other on bared soil. Therefore the trials tested were four in total. Two for the combination infiltration/soil covered by crop, the other infiltration/soil not covered by crop. The other two combination were sprinkler/soil covered and sprinkler/soil not covered.. Undisturbed soil samples (Ap and Bw) were taken at beginning of the experiment, during the irrigation season and at the end of the experiment. The samples were impregnated with resin containing a fluorescent dye and, after hardening, image analysis techniques and standard soil micromorphology were applied on the soil block. Between the main results there are relevant changes in the pore size distribution between the different treatments.

Key words: irrigation practices, pore geometry, image analysis.

Soil macroporosity dynamics under surface irrigation

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Abstract

Soil structure strongly affect water flow and solute transport, yet little information is available concerning soil hydraulic properties close to saturation. The pore size distribution and continuity in the top soil is greatly influenced by tillage practices. For example ploughing may disrupt the continuity of the macropores and at the same time lead to the formation of a plough pan (Messing and Jarvis, 1993). During the crop cycle, the macropore system is a result of a dynamic balance between processes like structure reconsolidation and root development (Beven e Germann, 1982).

This study reports detailed measurements of near saturated hydraulic conductivity in an undisturbed field soil under moldboard plough with the objective of determining *in situ* effective macroporosity and mesoporosity and its dynamics during the irrigation season. Field experiments were performed with a tension infiltrometer (Ankeny *et al.*, 1988). Nine measurement locations were spaced in a grid pattern approximately 30 cm apart. In each location an infiltration sequence was performed corresponding to water tensions of 3, 6 and 15 cm. To this range of tensions is associated a range of pore radius between 0.5 and 0.1 mm, considered to be both hydraulically active and important for the transmission of water and solutes (Smettem and Clothier, 1989; Ankeny *et al.*, 1990). Five sets of infiltration measurements were made at the soil surface between May and September. One set of measurements was made at the depth of 30 cm at the bottom of the ploughed layer.

The moldboard plow contributed for the origin of macroporosity till 30 cm depth, while breaking the continuity to the surface of the macropores located at this depth. After tillage 68 % of the flow occurred through the macropores. Once the ploughed layer becomes saturated, what is expected in the basin irrigation, the macropores at 30 cm become effective for the preferential transport of 46% of the infiltrating water. With the first irrigation the reconsolidation of the soil structure originated a decrease of 30 % in the macropore contribution to the flow. After this the irrigation effect was superposed by the root development effect creating new channels or creating continuity between existing pores.

Key words: preferential flow, macropore flow, tension infiltrometer

Influence of physical and hydrological qualities of hilly soils upon vine phenology. A study for the vine zoning of the Province of Siena

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Abstract

In the territory of the Province of Siena (Central Italy) studies for the viticulture suitability evaluation were performed and an experimental test was developed aimed at characterising the physical and hydrological properties of some benchmark soils under specialised vineyards. In these vineyards, also vegetation and yield data were recorded, in order to relate them to the measured soil qualities. In fact, previous studies have shown that such properties are important functional factors for the determination of vine's quantitative and qualitative response to different environmental conditions.
On the basis of a reconnaissance survey of part of the Province of Siena (scale 1:100.000), eight experimental vineyards, located in 5 different farms, were selected, whose soils represent some of the main typologies for the viticulture. For the selection of the vineyards, different parameters were taken into account, among which vegetation and plant homogeneity (planting density, training systems, canopy, number of buds per plant), age and proximity to meteorological stations. In the selected fields, soils were studied in detail and eight soil profiles were described, sampled, analysed and classified. Besides routine laboratory analyses, bulk density (core method), moisture content at different matric tensions (sandbox and Richards pressure plate extractor), aggregate stability (wet sieving) and coefficient of linear extensibility (COLE) were measured. Two undisturbed soil samples were taken from each soil horizon for macroporosity measurements by image analysis on soil thin sections. Soil moisture was gravimetrically measured, twice a month for one year, at two depths. The functional Epic model was utilised to produce a daily estimation of the soil water status. Phenological phases were monitored on vines (control and registration of: bud-break, flowering, veraison, ripening) as well as yield performance: grape yield per vine and vigour of plant (pruning weight). The must obtained from the harvested grapes was submitted to chemical analysis to determine the main analytical parameters (sugars, titratable acidity, pH). The tested soil showed, as expected, different hydrological behaviour. In particular, summer moisture deficit and autumn to winter saturation periods were significantly different according to the various soil typologies. Image analysis confirmed the trend of some soils to be prone to prolonged periods of water saturation. Besides soil water status, also soil structure seemed to be a functional quality for vine. Both parameters influenced phenology and yield of vines, which can have an excessive vegetative growth. Soils with a good summer water supply and structure are more productive, but also show vegeto-productive imbalance (high shoot growth, high leaf surface/yield ratio, low sugar content and acidity), which are considered negative for the obtaining of high quality wine.

Key words: soil hydrological properties, soil thin sections, vine phenology, Siena province.

Development of slopeland vegetable farming in agroforestry area

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Abstract

Agriculture is practiced with attention to reduce degradation and low environmental quality. Improved agricultural practices is not only aimed at high production and profit but the most important is socially acceptable and environmentally compatible. Appropriate technology adopted for upland and high land agriculture with special reference to conservation aspect is necessary to minimize soil degradation.

In order to protect the area from damages, appropriate land use is the simplest method. The alternative and recommended commodity should be determined based on land evaluation method and conservation input. The study was conducted in Agroforestry area in Manting Sub-watershed East Java, Indonesia.

The result of the first study showed that the proper land use of the forest area (study area) b Watershed was: protection forest 383 ha (83.26 %), rivers area 11 ha (2.39 %) and limited production forest 66 ha (14.35 %). The agroforestry (social forestry) program is in 66 ha. Adopting appropriate farming system will promote balance ecological environment. In this study, appropriate farming practices include the adoption of conservation tillage, contour planting and ridge row system, selected crop rotation, improved crop and cultivars, use of mulch, balance use of anorganic fertilizer and organic matter, efficient weed control, integrated pest management method, good harvesting method.

The result of the study showed that the farmer practiced conservation tillage by using mulch and organic material. Minimum tillage method is also adopted since the cultivation area is in slope land. Planting use ridge row and contour system. In some plots, diagonal furrow was introduced to reduce erosion and also for farm transport. During the last three years the farmer cultivate more vegetable rather than other secondary crops. All production activities are done by manual. Farmers who involved in agroforestry program are practicing common cropping pattern which is suitable and tolerant to the condition given by forest estate company. Some crops are not advisable to this area because their characteristics are not suitable for the conservation purposes. The level of production input is recommended by extension supervisor.

Degree of land degradation in upland and highland area of study area will decrease if the farmer adopt the proper agriculture and conservation practice. By practicing appropriate farming system in combination with some rehabilitation and conservation techniques, it is expected that the target of sustainable development with high production and environmentally sound agriculture could be achieved. Beside using conservation tillage, contour planting and ridge row system, some more conservation techniques are recommended. Data on erosion prediction is available so the rehabilitation and soil conservation practices can be determined. Institutional support is important in the form of extension services, financial/credit, and policy. It may be from village cooperative unit, Land Rehabilitation Center, Forest Estate Company, etc. as it is integrated issue.

Key words: Agroforestry, land use, conservation.

Soil conservation and management of arid soil in Kuwait

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Abstract

Soil of Kuwait is mostly sandy in texture with shallow horizons and contains high calcareous materials within the lower layers. Overgrazing, gravel mining, and vehicle movement through the fragile soil enhanced winds erosion and increase sandstorm occurrences. High evaporation (3000mm/year) and low rainfall (100mm/year) during the year limited native plant growth and increase soil mobility through wind movement with enormous environmental hazard to the urban areas. Soil erosion is a common habitat of arid zone, but the phenomena has tremendously increase with man interfering with the natural setting of the environment, introducing new destructive mining equipment, four wheel drive, overgrazing, and oil pollution. Sandstorm and soil movement in Kuwait affected various aspect of life and industrial development within the country. Most of the roads, oil refineries, desalinated seawater factories, power station, and all the urban areas are totally influenced by soil erosion and windstorm movement. The paper discusses the soil properties in Kuwait and wind movement with some solution for soil management in arid area to decrease soil erosion and improve the urban environmental condition.

Key word: sandy, horizon, overgrazing, gravel, sandstorm, evaporation, hazard, urban, pollution, erosion, windstorm.

Contribution of conservation tillage systems to the improvement of soil physical properties in South Portugal

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Abstract

Soil degradation in South Portugal is mainly the result of water erosion and intensive soil cultivation on the undulated fields of this typical Mediterranean region. The multiple effects of this kind of soil degradation have been clearly identified and conservation tillage systems established in order to study their potential contribution to the improvement of several selected parameters.
Different tillage systems, including the traditional one based on the mouldboard plough, reduced non inversion tillage and direct drilling, have been studied over the last 16 years for the assessment of their effects on different soil characteristics.
The results of several studies carried out on different soil types are presented and discussed in the frame of their relevance to soil conservation. Regarding the main concerns of soil degradation the following parameters are focussed: splash detachment, water infiltration and sediment transport; aggregate stability, soil pore system and its distribution.
The main conclusions drawn are that conservation tillage, and especially direct drilling, can contribute both, immediately through the reduction of surface runoff and sediment transport, and at medium and long term through the establishment of a favourable and stable soil structure, to the impediment of further soil degradation and even to an improvement of soil physical and chemical characteristics.

Key words: soil degradation, soil physical properties, tillage systems, direct drilling

Content of readily-dispersible clay in the arable layer of some Polish soils

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Abstract

Agricultural soils in Poland are monitored periodically to provide information about their condition. Until now, this monitoring has involved measurement of soil particle size distribution, and a wide range of chemical properties. This has been done using samples collected from many points distributed over Poland for all soil horizons down to typically 1.25 m. We have now extended this to study the content of readily-dispersible clay in the plough layer (0-200 mm depth) of these soils. Dispersed clay is important because it is an indication of soil instability and because it can transport associated nutrients and other pollutants.

Dispersed clay has been measured in the laboratory using a Hach 2100AN ratio turbidimeter. This measures the amount of colloids in suspension by measuring the amount of white light which is scattered at an angle of 90° to an incident beam of light. The measurements are independent of solution colour.

We make two types of measurements. In the first, we completely disperse the clay using the same technique which we use to measure the clay content, C g/100g, of the soil using the conventional hydrometer technique. After letting the sample stand for about 16 hours, we sample the suspension at 30 mm depth and measure the turbidity, T, (which is expressed in nephelometric turbidity units or NTU). Regression yields the calibration equation:

$$T = (4.69 \pm 0.22)\ C,\ \text{NTU/(g/L)},\ p < 0.001$$

To measure content of readily-dispersible clay, RDC, we use the same concentration of sample in a 150 mL plastic bottle and add 125 mL of distilled water. We then invert the bottle 4 times to give a total energy input of approximately 100 mJ to the system. We then let the samples stand and measure the turbidity as described above. We then express RDC as g/100g soil.

We have found that when we look at the soils of Poland, the values of all the properties which we consider (e.g. clay content, organic matter content, exchangeable cations) are log-normally distributed. Therefore, it is necessary to use the logarithms of the values in regression equations. When we do this, we find that:

$$\text{Ln(RDC)} = -1.36 + 0.51\ \text{Ln(C)} - 0.48\ \text{Ln(OM)},\ p < 0.001$$

where OM is the organic matter content of the soil in g/100g.

Correlations, although not highly significant, between Ln(RDC) and Ln(exchangeable cation content) for Ca, Mg, K and Na are: negative, zero, positive and positive, respectively.

Key words: dispersible clay, turbidity, organic matter, exchangeable cations, log-normal distributions.

Soil Structure influenced by management practices: case study

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Abstract

Despite long recognition of soil structure importance in defining soil quality and for plant growth, there are still ambiguities in its definition and in the criteria for the measurements. The purposes of this paper are to define soil structure and to quantify the changes occurred over years, under cropping systems in specific conditions. The study was conducted at the Irrigated Crops Research Station Valu lui Traian ($40^0$11'N, $28^0$30'E). This is an area with semi-arid climate, intensive agriculture under irrigation regime The Typic Vermusttol (USDA Taxonomy); has about 3% organic carbon, 35% clay content, pH_{H2O} 8.00, and 28.5 (me/100 g) total exchange capacity, 98.0 (me/100g) degree of base saturation. The soil in profile is loose, well drained. The long-term experiment has been set up in 1970, is organised in randomised complete blocks with split plots in four replicates, being of the type 3x4x4. The treatments applied: crop (wheat, maize, soybeans), manure (0, 20, 40, 60 t/ha), mineral fertilisers (N_0P_0, N_0P_{50}, $N_{50}P_{50}$, $N_{100}P_{100}$). Samples collected from 12 treatments (except N0P50) after wheat harvesting in summer 1999. It was measured: granular size distribution, water stable aggregate amounts, dispersion index, bulk density, porosity, resistance to penetration, saturated hydraulic conductivity, organic carbon, pH_{H2O}, total nitrogen, available phosphorus, number and types of bacteria and fungi. In our methodology are necessary main chemical and biological properties for to explain soil "structure" modification over years. In this way we can obtain a clearer picture of the properties and critical limits in characterisation of what we named "soil structure". Concerning the soil structure concept, in our country, this is not quite well defined, and we have not a good and generally applicable method for the quantitative characterisation of the status of soil structure. Nevertheless, in our agrophysical studies we distinguish, those aspects, which affect the topsoil, i.e. these features responsible for the entrance and exit of water and gases, and in the subsoil which is storage body for water and nutrient reserves of plant life we take into account porosity, permeability, water retention.From the data have been point out that in the topsoil the amount of water stable aggregates was not change due to the application of any treatment, having critical values, despite of the favourable genetical factories and formation processes of the structural aggregates. The research results are in agreement with the data obtained in "soil monitoring" system at the large scale, and with visual observation of farmers and pedologists. Nowadays, in this area on soil surface negative processes as: silting, sealing, crusting are common phenomena, affecting plant response mainly in the first vegetation stages Into soil profile the most important modification was in increasing the content of organic carbon under maximum manure dose. Other properties have presented only a positive tendency under all treatments. All data obtained have shown that in the cropping systems, for improving and maintaining soil physical conditions, i.e. soil structure quality is necessary to apply each agricultural component according to local conditions. In the experiment was used over years conventional tillage works which was not proper according to soil characteristics, having a particularly vulnerability to destructuration. Therefore the positive magnitude of the expected results was not according to treatments applied. There is still much more need in clarification of soil structure concept in our country, and in to promote proper cropping system in combination with conservation tillage.

Ski slopes and stability of soil aggregates

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Abstract

During the last ten years, in alpine ski resorts, the extension of ski slopes was increased to satisfy a growing tourist demand. The frequent grooming of the snow cover by heavy machinery, has raised some concern about the impact of snow management on soil aggregates stability. In alpine regions the snow cover may represent an important fraction of annual precipitation and a great amount of water may be released during spring snowmelt, affecting soil aggregates stability, since water is the main agent of aggregate breakdown.
The main goal of this research is to evaluate how land use and chemical properties may affect the soil aggregates stability.
The study area is represented by a ski slope, located in NW Italy (45°50'N and 7°49'E) and created in 1954. Soil samples were collected in five *transects* between 1450 and 1700 m a.s.l.. In each site, soils were sampled on the slope and in undisturbed conditions, a relatively pristine forest cover (*Abies alba*, *Picea abies*, *Pinus cembra*).
Soil samples were analyzed to determine soil texture, pH, EC, CEC, C_{org}, nitrogen and iron forms. The loss of standard aggregates (1-2 mm) was determined by wet sieving, after air-drying.
A simple exponential model has been recently proposed to quantitatively evaluate the aggregate breakdown (Zanini *et al.*, 1998 Soil Sci. 163:288-298). The model conceptually refers to a system where dry standard aggregates are gradually wetted, flooded and subjected to the disruptive action of both flowing water and eroding suspended material. For the practical purpose of estimating the more appropriate values for the model parameters from experimental data, we assumed that the breakdown of the aggregates followed the positive definite equation:

$$y(t) = a + b\,(1 - e^{-t/c})$$

where y is the aggregate breakdown or loss; t the time of abrasion; a initial loss of the pre-wetted aggregates; b the maximum loss of aggregate; and c is a time controlling factor.
The stability of soil aggregates was significantly higher in the undisturbed conditions than on ski slopes. In all sites the loss of standard aggregates was inversely correlated with clay and organic matter contents.
Snow management on ski slopes seems therefore to affect soil aggregate stability and the addition of organic matter may improve soil physical conditions.

Key words: ski slope, snow management, snowmelt, soil aggregates stability

Effect of repeated shallow disk tillage on some crop production factors on brown forest soil

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Abstract

Disks have been in use in Hungary since around 1890. Since they can be used in a variety of ways they are the second most widespread tillage tool after ploughs. The application of disk tillage in Hungary can be divided into four periods. In the first half-century period (1890-1940) disks became popular and disking became a normal part of the tillage system. For a short period between 1950 and 1960 strong reservations were expressed with respect to disking, but during the third period (1964-1988) disking, particularly basic disk tillage, became an acknowledged method of rational, cost-saving tillage. During the fourth period, since 1989, disking has often been used as a low cost form of tillage despite the serious damage to the soil status caused by compaction in the case of repeated disking. In order to demonstrate the changes in soil status caused by disking and to estimate the consequences on these changes, experiments were set up in Gödöllő in 1992 (A) and 1995 (B) on brown forest soil, with identical tillage and mineral fertilisation treatments. This paper examines the effects of disking and of disking combined with medium deep loosening on the soil status, on the yields of maize and winter wheat, and on weed growth. Data available in the literature prove the favourable effect of loosening on the yields of crops sensitive to the soil status when grown on soils which are liable to settle, so the present paper does not deal with this aspect of the problem, but with the long-term advantages and disadvantages of the two types of tillage, neither of them involving ploughing, with regard to soil status and weed growth. It could be seen from the results that disking was capable of developing the soil status required for crop production to a depth of 16-20 cm. The annual repetition of this shallow tillage method led to a compacted soil layer below the disking depth from the 3rd year onwards, which thickened towards both the surface and deeper layers from the 5th year, thus reducing the maximum depth which could be influenced by disking. The combination of disking with loosening was investigated to determine whether it could be used to avoid the unfavourable effects of long-term disking. The studies confirmed the beneficial effect of loosening on the physical state of the soil, but it was found that on the Gödöllő soil, which tends to settle, the effect of loosening was only felt for a single season or less. The compacting effect of disking after loosening could be attributed to the rainfall and soil moisture content during the cultivation season. The influence of mineral fertilisation on the yield of both crops in both experiments was in agreement with the literature. The yield of winter wheat was 13.5 % and 16 % greater after soil loosening in the two experiments, each over the average of 2 years. It was found that the yield-reducing effect of shallow disk tillage increased over time as the soil status deteriorated. In maize the long-term use of shallow disk tillage led to an increase in the weed cover, while the regular application of soil loosening proved to help control weeds. This weed-reducing effect was not as great as that of regular ploughing, but should be considered in addition to the yield-increasing effect when objectively judging the effectiveness of soil loosening. All in all a similar tendency could be observed in winter wheat though nine of the thirty-two disking treatments did not lead to greater weed infestation. In the experiments despite the repetition of tillage methods without ploughing, weed infestation was successfully overcome until the end of the 1998 growing season by applying a maize – winter wheat crop rotation.

Effect of long term tillage management changes on soil mechanical properties and ecological soil functions

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Abstract

The effect of changes in tillage treatments on the mechanical and ecological soil properties has been often discussed and argued under very different aspects.
During a special research project which was carried out for more than 9 years, we determined the effects of changes in the tillage system from conventional to conservation tillage (Horsch system) on the precompression stress values, changes in the Mohr Coulomb failure line parameters and the changes in hydraulic and air conductivity as a function of soil depth and time. It can be shown, that after approx. 4 years of continuous different treatment the conservation tillage plots started to show significant differences to those of the conventionally treated ones which can be explained by a complete rearrangement of soil structure. The detailed informations and recommendations will be given during the lecture.

Changes of mechanical properties due to soil freezing and thawing

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Abstract

A soil system is a combination of solid material, liquids, and gases. The solid materials of various geometries form the soil skeleton, interspersed with voids. Theses voids – the soil pores –contain liquids, gases, ice or a mixture of all. The moisture within the soil plays a major role for soil properties and processes associated with phase change. The freezing temperature of the soil water is determined by the soil matrix, particle size, content of organic material and the composition of the soil water and varies from soil to soil.
Composition and structure of soils as well as conditions of freezing determine water transfer and ice formation in the soil and therefor the developing pressure during freezing. Freezing of a soil can produces an effective stress and consequently a consolidation of the soil matrix. This effective stress originates from the suction developed in the pore water and an elevated pressure of the ice. Therefore, compressible soils may consist of consolidated aggregates, separated by ice lenses or other forms of segregated ice. Coarse grained soils show practically no liquid moisture migration during freezing and the vapour transfer is not sufficient for the formation of segregated ice. Determination of the unfrozen water content during freezing and in frozen soils was performed by a general phase composition equation on the basis of the specific surface area of the soil.
Tests carried out in the laboratories of the University of Kiel help to predict freezing induced changes of the soil properties. A sandy clay loam and a loamy sand (Samoylov Island) are used in an experimental set-up which enables mono- and bi-directional freezing of structured and unstructured soil cores (706 cm^3). The tests consist of three freeze-thaw cycles, each at a different reference temperature (-5°C, -10°C and –15°C), and last for 5 to 6 weeks. The thermal regime, changes of the unfrozen water content and the stress state of the soil are logged automatically in time steps of 10 minutes.
The recorded pressure, in dependence on the soil water/ice content and the soil composition, enables us to predict freezing induced changes of soil properties. These information are needed for a better characterisation of stress situations in the habitat of soil microbes.

Response of structure to trampling of woodland soil

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Abstract

Compaction by animal trampling influences many soil properties. This work was aimed to determine the effect of four compaction levels on some parameters describing soil structure. The study was conducted on fine-textured soil (50% clay) – from hillside broad-leaved coppice characterised by *Quercus petraea*. The control plot was undisturbed (C), the others were given one (C_1), two (C_2) and three (C_3) dynamic compaction treatments simulating cattle trampling. All plots were seeded with *Lolium perenne and Phleum pratense*. The samples for measurements of soil water retention, penetration resistance, water stability and sorptivity of soil aggregates were taken from two layers (0-10 and 10-20 cm).
An increase in soil compactness resulted in lower total porosity, air permeability and higher penetration resistance. Most of the decrease in porosity was due to reduction of pores greater than 100 μm. The effect of soil compaction on penetration resistance was related to soil water status. For example, in moist soil the penetration resistances in C and C_3 treatments were 0.3 and 2.9 MPa. For dry soil, the values were 0.9 and 6.1, respectively. Water stability of soil aggregates was highest in compacted soil and their sorptivity – in loose soil. The effect of soil compaction on all the properties was more pronounced in top 10-cm layer than in deeper soil. This research and the early results on a loamy soil suggest that there are considerable differences in response of soil structure to soil compaction based on soil type.

Key words: hillside soil, trampling, soil structure.

Properties of brown coal and its usability for improvement of soil structure

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Abstract

Very light soil is too porous and remains dry. This is a result of poor granulometric composition, in which sand is a dominant fraction whereas the content of silt and colloids does not exceed 10 per cent. Very light soil accounts for a considerable proportion of arable land in Poland, therefore methods for improving their productivity have been searched for. One of such methods is agromelioration treatment with brown coal which has a positive effect on water soil properties. This results is due to such properties of brown coal like very strongly developed porosity structure and their capability to ions exchange. Doughty variety of brown coal has high content for humodentrynite macerals which provide the earthy and porous texture and steaming moisture between 50% and 60 %.

The aim of this paper was the analyse of changes of physical and water properties of very light soil after application of preparation obtained from brown coal.

The long-term experiment was carried out on rusty soil formed from friable sand. Soil of the experiment had low retention of water, big permeability and porosity. The preparation contains 85% of brown coal, was applied into the soil in autumn 1987 in dose 80,0 $t \cdot ha^{-1}$ or 160,0 $t \cdot ha^{-1}$. Soil samples with non-disturbed structure into the measuring 100 cm^3 cylinder were collected from Ap horizon layer (0-25 cm) every year after crop harvesting. Bulk density by piknometr method were determined. Porosity total was counted on the base of bulk and specific density.

It was found that the preparation obtained from brown coal remarkably influenced on physical and water properties of very light soil. The treatment caused a decrease in bulk density of arable layer of soil in first year (1988) after applying of this fertilizer and so on in next years (1992, 1995) with the dose increase. Specific density was not changed under influence of this preparation. Porosity total increased after agromelioration with preparation obtained from brown coal on the some level in experimental year (1988, 1992 and 1995). The increase in soil retention of water was observed also.

Thus, the results obtained are promising and further studies should be carried out with brown coal for soil cultivation and improvement of water properties of very light soils.

Key words: brown coal, soil properties, sands soil.

Improving Mediterranean soils physical properties by using Anionic Polyacrylamide in the irrigation water

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Abstract

Of the 870 000 irrigated hectares in Portugal, 85% is under surface irrigation and primarily furrow- irrigated (74% of the total irrigated area). Mediterranean soils are very typical of the irrigation districts in Southern Portugal, where they represent 40% of all soils. The particular characteristic of the Mediterranean soils is a rapidly permeable A- horizon overlaying a B- horizon of very low permeability. If the wetting front under irrigation encounters this zone of low permeability, it significantly reduces infiltration and the soil infiltration rate becomes limited to the low permeability of this B- horizon.

Due to the soil conditions at the surface (texture, structure and low aggregate stability), infiltration rate generally decreases significantly after the first irrigation event. This fact is due to the rapid advance velocity of the irrigation water, which induces more sediment loss and runoff and thus crust and seal are easily formed.

In the Mediterranean climate and for irrigated crops improving the aggregate stability by increasing soil organic matter content is limited by the high rate of mineralization, and the high value of agricultural residues such as straw. This cost limits the use of crop residues and artificial covers to small areas of highly intensive agricultural production (Ferreira *et al.*, 1994). For these reasons there is increasing interest in materials that are able to improve soil physical characteristics such as aggregate formation and stability. Water-soluble soil conditioners like anionic polyacrylamide (PAM) can bind with clay through divalent calcium (Wallace and Wallace, 1990). The objective of the present work was to determine whether the use of polyacrylamide in the furrow irrigation is an alternative to the improving of physical properties (structural stability, porosity, hydraulic conductivity) in a Mediterranean soil.

One field was established on contour terraces with uniform slope of 0.2% and furrows 180 m long. In another field, slopping furrows of 1.2% average slope and 140 m length were established. On both fields, an high molecular weight anionic polyacrylamide (PAM, Superfloc A-836 by Cytec industries) was applied with the irrigation water to randomly selected furrows to achieve a concentration of 10 ppm (gm^{-3}) in the stream flow. In each field 3 furrows per treatment were controlled.

On average, soil loss in the first irrigation was around 17 ton/ha in the tail end of the slopping control furrows, against 0.7 ton/ha on the contour control furrows. Use of PAM in the first irrigation, decreased soil loss to 3.6 ton/ha in the first case and to 26 kg/ha in the second one. PAM application increased soil aggregate stability, reduced soil crusting, and had an average increase in infiltration of 85% was observed in the treated slopping furrows and 50% on the contour furrows. The use of disc infiltrometers also shows that the use of PAM increases effective porosity of the soil macropores in 47% and mesopores in 46%. The saturated hydraulic conductivity also increased 27% when PAM was applied in the advance phase of the first irrigation.

Key- words: Furrow irrigation, polyacrylamide, soil loss, infiltration and porosity.

Sand size organic matter content as an indicator of early changes in the stability of macro aggregates in the 0-5 cm layers of the savannah soils in North Cameroon

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Abstract

The effects of agricultural land use histories (LUH) on the stability of macro-aggregates (4.0-4.8 mm) in the 0-5 cm soil layers were investigated on the main savannah soils in North Cameroon.

On each soil, bulk soil samples were randomly collected from the 0-5 cm layers of the selected land use histories. From each soil sample, air-dried macro aggregates 4.0 to 4.8 mm were sieved and subjected to slow moistening on a sand bed at pF 1 for 24 hours. Macro-aggregate stability to water drop impacts (WDI) was determined and the mechanisms of disaggregation described. The stability of bulk soil samples from the same plots to wet sieving was also determined and results expressed as mean weight diameter. Soil samples (< 2mm) were fractionated into sand size and sedimentary silt and clay fractions and the respective percentages of organic carbon and nitrogen measured. Empirical linear relations between the macro aggregate stability index (mJ) and percentage organic carbon in the soil fractions were established.

Macro-aggregates from fallow and zero tilled cropped soils disaggregated in a stepwise manner. The initial drop impacts broke each macro-aggregate generally into 2 to 4 smaller aggregates that disintegrated with further drop impacts. Macro aggregates from ploughed cropped soils comminuted in a rather one step manner into micro-aggregates and primary particles.

Macro aggregate stability index (ASI_{50}) of samples from ploughed soils was generally lower (10.0 mJ) and higher 16-27 mJ in fallow and zero tilled cropped soils. In Chromic Luvisol and Eutric Planosol, the mean weight diameter (MWD) was respectively 447 and 352 mm in fallow soils and 188 and 242 in cultivated soils.

The stepwise disintegration of macro-aggregates indicates the existence of a range of aggregates of varying sizes and stabilities and of hierarchy of aggregation within the size range 2 to 5 mm. Higher values of (ASI_{50}) and MWD indicate a higher proportion of stable macro-aggregates in the soil.

Sand size organic carbon and nitrogen contents were significantly higher in the fallow and zero tilled relative to cultivated soils. Macro-aggregate stability index expressed as a function of the percentage of organic carbon, had the best correlation (R^2= 0.670) with sand size organic carbon content.

In these low organic matter mineral soils, changes in sand size organic matter content could therefore be a better early indicator of changes in the stability of macro aggregates to raindrop impacts, slaking and plough implements.

Key words: Aggregate hierarchy, aggregate stability index, land use history, sand size organic matter, water drop impact

The influence of clay size on clay dispersion of Alfisols

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Abstract

The effect of clay size of four Alfisols, equilibrated with NaCl / $CaCl_2$ solutions of different total concentration (C = 5, 10, 50 and 100 mmol/L) and different sodium adsorption ratio (SAR = 0, 5, 10, 20 and 40 $(mmol/L)^{1/2}$), on clay dispersion was investigated.
Suspensions of equilibrated soil samples in solutions similar to equilibrating solutions or in de-ionized water were received a minimum (30 sec) or prolonged (16 hour) shaking. After shaking the dispersed clay fractions of 1-2 and <1 μm were determined by measuring the optical density (at 640 nm) of the suspensions after a relaxation time calculated from Stoke's law. The results of each dispersed clay fraction were expressed as a percentage of the same size clay fraction determined after conventional particle size analysis. Two replicates were used for each soil, electrolyte concentration and sodium adsorption ratio tested.
For all soils studied the results showed that for any electrolyte concentration, sodium adsorption ratio, time of shaking and dispersion fluid used, the dispersed clay fraction 1-2 μm, expressed as a percentage of the clay fraction 1-2 μm determined by particle size analysis, was always greater than the corresponding percentage of the clay fraction <1 μm. In most cases significant differences were obtained between the two clay fractions studied. It was also found, for all soils, time of shaking and equilibrating solution concentrations studied, that the critical flocculation concentration of the dispersing solution at a given sodium adsorption ratio, was higher for the 1-2 than for the <1 μm clay fraction.
The lower susceptibility to dispersion of the <1 μm clay fractions may be attributed to greater surface area of this fraction and the consequent increased free surface area which in turn increases the tendency of this fraction to flocculation. The influence of clay content and mineralogy, organic matter, Fe- and Al-oxides and hydroxides, pH and mechanical disturbance on differences in clay dispersion found between the soils, is discussed.

Key words: clay, SAR, dispersion, Alfisols

Fractal Dimension of a sandy soil as calculated by two different approaches from mercury porosimetry

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Abstract

Recent advances in fractal theory may be applicable to the characterization of soil porosity and soil structure. In this work fractal dimensions of both, the pore matrix (Dm) and the solid:pore interfaces (Ds) of a sandy soil rich in organic matter were calculated from mercury porosimetry data and the obtained results were compared. 15 samples were taken from the topsoil of five plots with different cultivation practices and tillage history. The study was conducted on an experimental farm located at Castro de Ribeira de Lea, near Lugo (N.W. Spain) and the sampling dates were February, June and October of 1989. Sample composition varied widely, both between and within sites. Organic matter contents were between 6.55 % and 14.46 %, sand contents between 57.3 % and 67.5% and clay contents between 12.6 % and 23.6 %. Pore distribution patterns were analyzed by mercury porosimetry. A Carlo Erba 2000 mercury intrusion porosimeter was used to determine the pore radii distribution from about 4 to 10^6 nm, using individual 1.7-2 g air dried soil aggregates. Fractal dimensions of the matrix (Dm) and the solid:pore interface (Ds) were computed by two independent approaches of the scale invariance based on the cumulative pore volume distribution and the cumulative solid:pore interface area, respectively. When considering Dm, two different domains of pore radius were found to exhibit fractal behavior. The radius of the first structural domain was approximately between 4 -10^3 nm and that of the second one between 10^3–10^6 nm. These domains could be related to different types of organization of the soil aggregates. Mean values of the matrix fractal dimension, Dm, in the first and second radii ranges were 2.982 and 2.919, respectively. The fractal dimension of the solid:pore interface, Ds, was calculated for most of the samples using the range of pore radii between 400 and 3.10^5 nm. Maximum and minimum Ds were 2.682 and 2.435 and the mean value 2.550. Thus, Ds values were lower than Dm values. No significant correlation was found between Dm and Ds data. The temporal variability of Dm or Ds values was scarce, which is in accordance with the limited shrinking-swelling ability of the studied soil during drying and wetting cycles. A moderate positive dependence between Dm values calculated in the10^3–10^6 nm pore size domain and clay content was found, whereas Dm values tend to increase as porosity decreases. This result could indicate that Dm depends on pore filling. Assessment of soil structure using fractal dimension as a modeling tool is discussed.

Key words: soil structure, seasonal sampling, fractal dimension, organic matter, mercury porosimetry

Impact of catch crops upon the soil structure and soil humus

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Abstract

The impact of selected green manure catch crops on the soil structure was analyzed in field trials at different periods since they were ploughed down. For evaluation the soil structure coefficients (relation among the agronomic valuable and less valuable soil aggregates) were applied. The structural stages of soils were found – beside the factors studied – to be strongly dependent on the soil kind at the experimental location, as well as on the weather conditions before extraction of soil samples.

A positive impact of catch crops ploughed down as compared with a variant without catch crops use, remained present in soils from the day, when catch crops were ploughed down, till the time of the following crop (spring barley) harvest; it however have no influence upon the grain yield and quality, presumably at the arid climatic conditions.

At the 35 years long lasting field experiments the impact of catch crops use (like white mustard, phacelia) was evaluated in the combination with the straw ploughed down in the cereals monocultures from the point of view of the soil humus content and quality.

Long lasting use of catch crops aimed at the increase of both the amount and quality of humus in soils. Contents of all humus- and humin-acids, as well as relation between humin- and fulvo-acids were increasing, namely if the straw was ploughed down simultaneously.

Our results are contributions to the research projects of the National Agency for Agricultural Research No. EP 0960006292 "Models of soil management systems in different agro-ecological conditions", as well as of EP 9098 "Catch crops in the system of soil management as the source of the organic matter, green land revitalization, and bio-diversity", supported financially by the Czech Ministry of Agriculture.

Effect of different soil tillage and organic fertilization on the soil structure

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Abstract

In a maize-growing region on medium-heavy chernozem were tested (going three years) five systems of soil cultivation in silage maize with different organic fertilization (farmyard manure, cattle slurry, straw + cattle slurry). Effect of different intensity soil tillage on the fractional aggregation of structural components was statistically significant. With raising up the soil tillage intensity increased the amount of agronomicaly less valuable aggregates (above 10 mm) and decreased the mild aggregates (0,25-10 mm) and in consequence the soil structure coefficient. The effect of organic fertilization on the soil structure was under conditions of fertile chernozem soil low, statistically not significant.

Soil structure of tilled horizons influenced by management practices and implement geometry

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Abstract

A clay-loam soil, Cambic Chernozem (Soil Taxonomy, 1994) developed in loess-like deposits, was studied, following the "soil tillage alternation" in a long term field experiment. The alternation of tillage occurred every three years. Four treatments (ploughing, chiselling, disking and no-tillage) were chosen for better understanding the influence of different management and implement geometry on soil structure changes as well as the natural mechanisms of structure restoration (freezing-thawing processes and faunal activity). Soil samples were collected from three depths of each plot: top horizon (Ap); "plough pan" (Aph) and A mollic horizon (Am).

The image analyses data showed that the soil structure had important modifications of micro- and macroporosity in the tilled horizons of all the four plots. The total porosity of Aph decreased drastically in all the plots. In Am horizons the total porosity increased again, but the value remained lower than those of the top horizons.

Implement geometry and kinetic induced to peds during tillage, highly influenced the pattern of spatial arrangement of soil structure and porosity.

The porosity and the patterns of spatial arrangements of the clods were influenced by implement geometry, as well as by the kinetic induced to the peds during tillage. Tilled layers, in ploughed and chiselled plots, comprised Ap and half of Aph horizons, while in disked treatment it coincided with top Ap horizon.

In ploughed soil, the furrow was reversed and compacted parts of Aph horizon arose to the surface, freezing-thawing processes induced their fragmentation (with an opened porosity). At the same time, part of more structured top horizon (Ap) ended into compacted Aph, improving its structure and porosity. Thus, ploughed plot had the highest porosity. In disked soil, the kinetic induced to the peds was high and a very compacted structure resulted. Ped kinetic of chiselled soil was very low.

Freezing-thawing processes and faunal activity were very important. In top horizons (Ap) the clods generated by implements were before fragmented by freezing-thawing processes (thus an open porosity result). For this, in all plots total porosity of Ap was higher than the other horizons; implement influences stressed the existing differences. Aph horizon still remained compacted, with a close-packed porosity. Soil fauna activity is relatively high in all the plots.

The maize yield was drastically affected by drought with respect to the tillage. During the draughty year (comparing with the normal one) the yield reduced 70% in ploughed and chisel and 30% in disked (were total porosity were lowest). Thus, the smaller porosity becomes a favourable factor for plant development in droughty years. The yield of normal year was higher in ploughed and chiselled and lower in disked and no-tilled. The highest maize yield was in extremely rainy year for all the plots. In disked and no-tillage the yield were lower than in ploughed and chiselled.

Key words: soil micromorphology, implement geometry, image analysis, structure.

Effect of soil deformation on stress and strain distribution and changes in physical site properties and functions

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Abstract

The determination of sustainable ecological soil properties under intensive farming systems must include the differentiation of both components of soil deformation. During repeated wheeling experiments of a Hiwassee clay loam under well defined soil bin conditions and on the research farm with Norfolk sandy loam in Auburn/AL, we determined not only the effects on stress and strain distribution under defined wheeling events with a tractor but also the corresponding effects of a rubber belt mounted at a gantry system in a Norfolk sandy loam.

The following results could be obtained:

1) The bulk density as well as the structure development including the rearrangement of soil particles mainly depends on the intensity and kind of soil deformation as well as on the hydraulic site conditions during wheeling.
2) The more often soils are wheeled and the more intense are the shearing processes the higher are the bulk density values, the possibility to rearrange soil particles and the potential of normal shrinkage,
3) Due to wheeling under both tire systems, the stress components as well as strain effects change and result in a complete variation of the material functions of the soil.
4) Especially under the rubber belt we could detect only small values of vertical stresses, while shear stresses dominate. Thus, the complete destruction of soil aggregation results in homogenised soil volume with a very tortuose pore system.
5) With increasing number of wheeling, even the values of the proctor density are exceeded by the newly formed fragments if related to the actual soil volume; the interaggregate pore systems are reduced to zero due to wheeling.

The results will be demonstrated as a poster.

Earthworms as promotors of soil structure rehabilitation

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Abstract

In temperate regions biogenic rehabilitation processes of degraded soil structure are mainly caused by earthworm activity. Within the soil profile, those processes result in burrows as new macropores and casts as newly formed aggregates. The present study quantifies the burrowing and casting of earthworms as ecosystem engineers in arable soil degraded by wheeling with heavy machinery.

The study was conducted in Germany at an experimental site on fields either tilled conventionally (CT) by a mouldboard plough or treated with conservation tillage (CS) without ploughing. Both tillage systems are applied for many years. The soil is a Luvisol of loamy silt derived from loess. The whole site is characterized by a high earthworm population of about 30 ind. m^{-2} on average. Plots of both fields were wheeled track by track 6 times with a wheel load of 5 Mg at field capacity (pF 2.2) in spring 1995. Immediately after this event and 2 years later undisturbed soil monoliths (23 cm deep, 12 cm in diameter) were excavated from wheeled (compacted) and unwheeled (uncompacted) plots of both fields. The macropore system was analyzed by X-ray computed tomography. After defaunation some monoliths were separately inoculated with 2 earthworm species: *Lumbricus terrestris* and *Aporrectodea caliginosa* to study species specific effects. Casts of both species were collected to measure their porosity and relative water stability. Furthermore, the annual cast production was calculated from species casting rates (laboratory data) and species biomass (field data).

The total length, volume and tortuosity of macropores decreased for about 80 % due to the wheeling event. Two years later, these parameters increased in CT plots more than twice and more than 4 times in CS plots compared to uncompacted plots. Relating macropore parameters to earthworm species a macropore continuity of about 70 % was calculated for the anecic *L. terrestris* and about 10 to 20 % for the endogeic *A. caliginosa*. The porosity of earthworm casts was 10 to 20 % higher compared to soil aggregates. Generally, the relative water stability of casts and aggregates was higher in compacted compared to uncompacted plots. Casts were about 10 % less stable than soil aggregates. In sum, *L. terrestris* and *A. caliginosa* produced casts of 10 Mg ha^{-1} y^{-1} in unwheeled plots of both tillage systems. In case of wheeled CS plots a cast production of 17 Mg ha^{-1} y^{-1} was calculated compared to 3 Mg ha^{-1} y^{-1} for unwheeled plots.

In conclusion, rehabilitation processes of degraded soil structure are initiated and accelerated by earthworms as ecosystem engineers most effective under conservation tillage.

Key words: earthworms, soil structure, rehabilitation, macropores, soil aggregates

Results of the first year of tests on soil physical-chemical properties following different fertilization systems

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Abstract

The following study, that gives the first year results of the experimentation about biomass using on soil following agricultural machines passes for the recovery of the functional quality of the soil and that will continue for at least three years, was conducted in a large farm near Rome, about 3 km from the sea (41° 55.434 Latitude North, 12° 12.058 Longitude East, South vertex of plot tested) The top-soil (Ap, 0-30 cm) was characterised on the average by neutral - alkaline reaction, sand - loam texture and well endowed of the main fertilising elements, due to fertilisation. In this paper, treatments, considered on a completely randomized bloc (six treatments for three replications) were: Control = no fertilisation ; S.S.1 = 7.5 t ha $^{-1}$ d. m. year of sewage sludge; S.S.2 = 22.5 t ha^{-1} d. m. year of sewage sludge; O.M. = 32 t ha^{-1} of organic manure; Mi.F. = mineral fertilisation (160 kg ha^{-1}); F.M. = farm manure (200 kg ha^{-1}). Each plot was 10 x 6 m large (60 m^2 area).
In this study, measurements were made on each plot and parameters measured included: maize yield (t ha^{-1}); soil penetration resistance (MPa), bulk density (Mg m^{-3}), soil shear strength (kPa), aggregate stability index (%), organic matter (%), cation exchange capacity (meq 100 g^{-1}), exchangeable cations (% CEC),
First results obtained showed some significant correlation between maize yield and physical – chemical properties; in particular, treatment S.S. 2 (22.5 t ha^{-1} d.m. year of sewage sludge) showed: higher production, lower values of penetration resistance and dry bulk density and higher values of organic matter, also if a lower aggregate stability index was found.
The primary objective of this study was to investigate soil physical-chemical qualities and maize yield following different fertilisation system. The second objective was to develop statistical correlation for the soil layers tested between maize yield and physical-chemical properties.

Key words: soil physical properties, soil chemical properties, ferilization systems, sewage sludge

Sorption, ions exchange and dispersion processes are defined by the soil pore space structure

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Abstract

Introduction. Matter transport modelling in vadose zone of the soil is a key position in soil management, contamination, etc. Coefficients of sorption, ion exchange, average solute particle velocity and dispersion coefficient are the main parameters of convection-dispersion transport, determined as usual on soil columns by the breakthrough curves. Field-scale transport experiments can made clear acceptibility of this approach to real conditions. The aim of this investigation is to study the distribution of sorbed (ion K), non-sorbed (ion Cl), neutral (starch label) in field filtration experiments according the space distribution of soil porosity in a scale soil individual.

Materials and methods. Field lysimetric experiments were conducted in clay-loam Grey Forest soil. Lysimeters 65x70 cm with cells 3x3 cm were installed on the different depth. Water filtrated from the surface to the moment of the appearance of the first portions of water in lysimetric's cells. Than 1 M KCl solution with 1% of soluble starch was added to the surface. The concentration of ions and starch were estimated in different cells of lysimeter. After filtration the space distribution of ions K, Cl, visible zones of starch movement and soil density were estimated on the grid with step 10 m in the zone of filtration on the soil horizontal sections (about 1x1 m) on different depths.

Results and discussion. Variability of density on the soil sections was very high: in the upper layers (0-30 cm) were zones with density from 0.9 –1.0 to 1.3-1.4 g/cm^3, in deeper ones – from 1.2 to 1.7 g/cm^3. Water filtrated through a special zones, forming preferential ways of movement due to space variability of soil porosity: water preferentially moved not through the loosest zones, but through the category of porosity which had the most equalizing vertical positions. Accordingly, the zones of ions concentration were in the same space positions. The concentration of ions (K, Cl) in lysimetric water in positions of preferential ways of filtration were the same as solute application on the surface. The horizontal natural space distribution of the soil porosity in a scale of individual soil (pedon) determines the preferential flow formation and the processes of ions sorption and exchange.

Key words: lysimeter, space variabily of soil density, matter labels

Effect of organic matter application on soil properties in arid land of Kuwait

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Abstract

Soils of Kuwait contain little plant nutrients and organic matters to support plant growth and development. Soils water holding capacities are very small and need continuous irrigation to maintain water availability. Addition of organic matter in various soils of Kuwait in different time duration were observed and investigated. The effect of organic matter on soil physical and chemical properties were analyzed and compared within the soil solution. High variation of macro and micro nutrients were distinguish among different soils treatments with organic matter application. Plant nutrients increased in the soil solution with organic matter application enormously. Soil physical properties improved by the decreasing of soils bulk densities and increasing soil water holding capacities. Organic materials are available from many sources in Kuwait, mostly from animal, industrial and municipal waste. These materials can be utilized more efficiently for soil improvement and plants production. Most of organic materials in Kuwait are buried for disposal in limited and very expensive land. Converting organic materials to soils conditioners and fertilizer will improve soil capabilities and save the limited water resources available for irrigation.

Key words : Nutrient, organic, soil, Kuwait, solution, density, irrigation.

The impact of irrigation application upon soil physical degradation in Castilla-La Mancha (Spain)

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Abstract

The main objective has been to analyse the soil physical degradation in a test-site in Castilla-La Mancha that has been cultivated for twenty five years under irrigation to detect if the irrigation transformation and the continuous use of this exploitation system is a risk for the soil degradation. And if it is necessary to suggest activities to look after and recuperate these soils.

This work has been carried out in the area "Los Llanos", near Albacete (Castilla-La Mancha), where has been analysed the soil upper layers of six plots under pivot centre system.

Soils of this area have a kind of profile $A_p/B_k/C$, with a ochric horizon of 25 cm gross on a calcareous profile. According to FAO (1998) they can be classified like "haplic calcisols".

The soil physical degradation was estimated according to the system proposes for Sanchez et al. (1997) in soils of Castilla-La Mancha, which evaluates the degradation through a index composes by crust index (FAO-PNUMA, 1980), percentage of stable aggregates and retention capacity of available water.

The values of Degradation Physical Index (PDI) and the kind of physical degradation, according to the specific methodology, are in the next table to the six studied plots:

Plot	1	2	3	4	5	6
PDI	0.020	0.014	0.014	0.031	0.026	0.033
Classification	Low	Low	Low	Nearly low	Low	Nearly low

According to the results, it can not be said that the continuous irrigation is a factor that is going to influence on de soil physical degradation. This is because of the obtained index are more favourable than the same index in near dry areas, where the PDI shows a "high physical degradation".

Key words: soil degradation, soil quality, soil physical degradation, irrigation.

Reclamation of extremely cohesive mining substrates

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Abstract

Related large scale open-cast mining activities in the Lusatian mining district varved clays will be deposited within the next years. For example, at the mining site Nochten these clays are extremely cohesive and have varying contents of sandy substrates from interlayers conveyed and dumped without further separation. The present study aims at testing the suitability of varved clay substrates for forest reclamation purposes. An optimum mixture of sandy and clayey compounds is aspired to provide adequate physical and chemical soil properties as a prerequisite for a sustained forest production. Field studies have been carried out in old stands and on recently afforestated mine sites comparing plots with cohesive and less cohesive substrates on each. Experimental studies have been carried out to verify results from field experiments.

Substrates on experimental sites proved to be extremely heterogeneous due to the distribution of clay either as lumps or being intensively mixed with non-cohesive compounds. In general, the share of medium and macro pores decreased significantly as the content of varved clays in substrates increased. With increasing contents of silt and clay a significant decrease of the hydraulic conductivity and rates of infiltration of rain water on experimental sites was measured. Frequently slack water remained on top of the substrates. When subsequently falling dry encrustations and crack structures appear in the top layers.

The above- and below-ground biomass production of rye grass was tested under experimental conditions for mixtures of varved clay with either quaternary or tertiary sands. Biomass formation turned out to be higher for mixtures with quaternary substrate. For mixtures with quaternary sands also a clear correlation was found between increasing contents of varved clays and the decrease of root and shoot growth. On the contrary, by increasing the amount of varved clay in tertiary substrates a positive growth response occurred. Although biomass productivity was still on a lower level as compared to quaternary substrates it was assumed that for acid tertiary sands mixtures with varved clays may have a positive ameliorative effect.

In general, tree seedlings tested under experimental conditions showed significantly higher growth rates when mixing sands with 20 Vol. % as compared to 50 Vol. % of varved clay. This finding indicates that trees respond very sensitively to an increase cohesiveness of the substrate. Oak (*Quercus petraea*) and lime-tree (*Tilia cordata*) seedlings proved to be much better adapted to rather cohesive materials than pine (*Pinus sylvestris*), spruce (*Picea abies*) and larch (*Larix kaempferi*). Further studies are required to develop an optimum mixture for clayey and sandy substrates in order to provide both a maximum plant growth productivity and to facilitate cultivation of such substrates.

Key words: varved clay, post-mining landscape, forest reclamation, pore size, conductivity

Session: *Soil Hydrology*

Infiltration through crust topped soils: Henry´s effect

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Abstract

In earlier experiments on steady infiltration into crust topped soil columns, an additional resistance was observed in the vicinity of the boundary between the crust and the soil below. Later on, the increased hydraulic resistance of the top plate was mentioned in publications on laboratory study of infiltration into crust topped soils. I have performed laboratory experiments in order to check and, eventually, to explain this phenomenon. Crust topped soil was modeled in the traditional way by ceramic plate of high resistance placed on the top of the homogeneous fine sand column. Hydraulic resistance of the plate was by two orders of magnitude higher than the resistance of the soil column. Unsteady infiltration into crust topped soil of low and high water content was repeatedly realized and the plate resistance was measured before, during, and after infiltration. After infiltration, „saturated" flow in the system was performed and the flux in sandwich system plate-silt-plate was measured, too. Hydraulic resistance of the plate was rising with time during infiltration. The increase of hydraulic resistance was more expressed when water infiltrated into crust topped dry sand than in experiments with sand of high water content. Hydraulic resistance of the plate was rising with time even in saturated system and the increase of the resistance was dependent upon applied hydraulic gradient. However, the increase of the plate resistance was in this set of experiments less expressed when compared to infiltration into dry soil. The process of gradual increase of plate resistance was only partly reversible. Following hypothesis is applicable: Steep drop of the water pressure when water flows through the crust of high hydraulic resistance results in substantial difference of pressure in the top and bottom part of the crust. The concentration of dissolved air in water depends upon the pressure acting on water according to linear Henry´s law. Thus, at the bottom part of the crust a release of air in small, microscopic air bubbles occur due to substantial drop of pressure. The microbubbles are blocking the micropores of the bottom part of the crust and, consequently, hydraulic resistance increases. This effect exists provided that the crust porous system is uniform and consisting of fine micropores only. Adequate theory follows.

Key words: Infiltration; crust hydraulic resistance; Henry´s law.

Some aspects of soil seal modeling: approximations and their effect on the predicted soil water regime

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Abstract

The evolution in soil seal modeling is reviewed from the point of view of the basic assumptions and the consequent results. However, the focus of this presentation is on comparison between two different approaches to the solution of infiltration in sealed soil during the dynamic stage of the seal formation as well as when the seal layer is fully developed.
The first approach considers the soil seal to be the non-uniform upper zone disturbed by the rainfall, where all the hydraulic properties are depth-dependent according to the exponential model of Mualem and Assouline (1989).
The second approach replaces the non-uniform seal by an equivalent uniform layer, conceptually creating a well-defined uniform two-layer flow system. The dynamic of the seal formation is modeled according to Assouline and Mualem (1997).
The results indicate that the application of the two approaches are not fully equivalent in all terms. Some lines are drawn with regard to where and when the differences between the two solutions are negligible and where the differences are significant.

Key words: Infiltration, soil surface sealing, soil seal models.

A new conceptual approach in modeling the water retention and the relative hydraulic conductivity functions of soils.

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Abstract

A conceptual model based on the assumption that soil structure evolves from a uniform random fragmentation process is proposed to define the water retention function. The fragmentation process determines the particle size distribution in the soil. The transformation of particle volumes into pore volumes via a power function, and the application of the capillarity equation, leads to an expression for the water retention curve (WRC). This expression presents two fitting parameters only. The proposed model is tested on water retention data sets of 12 soils, representing a wide range of soil textures, from sand to clay. The agreement between the fitted curves and the measured data is very good. The proposed model exhibits increased flexibility and improves the fit both at the high and the low water contents range.

Based on the first two moments of the WRC expression, a simple model is proposed which predicts the soil relative hydraulic conductivity function (RHC). The RHC is a power function of the relative contribution of the pores filled with water. It is shown that the power value is related to the coefficient of variation characterizing the WRC. Therefore, a relationship is established between the RHC and the soil structure and texture, as reflected by the measured WRC. The model is calibrated on data from 8 soils and tested on data from 5 soils, representing a wide range of soil textures. The performances of the model are compared to those resulting from the application of Mualem's model (1976). In most of the cases, the proposed model improves the fit of the predicted RHC to the measured data.

Transport properties in soils related to local-scale heterogeneities: theoretical considerations and applications

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ABSTRACT

Soil soften exhibit a variety of small-scale heterogeneities such as cracks, inter-aggregate macropores and voids which partition flow into separate regions.
In this paper new approaches are discussed for characterising the hydrological behaviour of heterogeneous soils, in presence of structural inter-aggregate macropores or even shrinkage cracks. Accordingly, special emphasis is given to the effect of micro-macro-heterogeneity and soil structure on water and solute transport processes at local scale. The discussion is limited to the review of mechanistic approaches, known to be based on physical concepts and laws, and does not include the examination of transport of reactive and degradable contaminants in porous media.
Transport of inert solutes in the soil under both saturated and unsaturated conditions are investigated. Large undisturbed and variously structured soil samples underwent steady flow processes in the laboratory. The time domain reflectometry technique (TDR) was applied for detecting solute transport. Applied to soil samples of different textures and structures, the effectiveness of both equilibrium and physical non-equilibrium approaches for analysing of space/time distributions of the chloride ion concentration under different flow conditions are deeply investigated.
Flexible retention relations in describing the retention data of an aggregated soil are evaluated, with the principal aim of assessing their predictive capability for estimating the hydraulic conductivity function. The predictive capability of hydraulic conductivity is independently tested by using a broad set of unsaturated conductivity observations determined through the crust method. Results enable a detailed discussion on model parameterization and related parameter uncertainty to be made.
A new physically based simulation model of infiltration through swelling and shrinking soils is discussed in which Richards equation for describing flow through the matrix is coupled with the description of the shrinkage and of the flow of water along the cracks. Infiltration experiments specifically designed to calibrate the model were carried out on large undisturbed shrinking clay soil columns and at different inflow rates. Relevant results are also presented.

A compartimental approach for assessing the spatial variability of hydraulic conductivity within tilled soils

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Abstract

Agricultural practices, like tillage operations and wheeling by agricultural machinery, are known to enhance the spatial variability of soil structure and soil saturated hydraulic conductivity. This is especially true for cropping systems that include ploughing as a mean for controlling weeds, incorporating plant residues and increasing soil porosity. Recent advances have been done in the description of the structure of tilled soils by relating its morphological macroscopic features and their evolution in time to the agricultural operations expressed in terms of compaction, fragmentation and displacement of soil material. However, the link between this description and its relevance in regard to the hydrodynamic behaviour of tilled soils still needs to be explored.

The description of the soil structure is based on a compartmentalisation of the tilled soil as observed on a vertical plane of an access pit perpendicular to the tillage direction. The working width of the machines determines that of a soil structure motif that recurs laterally within the tilled layer of the whole field plot. This motif includes a vertical compartmentalisation (seed bed, ploughed layer, plough pan, and undisturbed soil) as well as an horizontal one (below a wheel track, between wheel tracks).

We conducted near-saturated hydraulic conductivity measurements using tension disk infiltrometry on each of these compartments. Measurements have been repeated on 9 large pits in a stretch of field encompassing the same tillage motif. In this way, we could statistically test the significance of such compartmentalisation by comparing the averaged hydraulic conductivity values of the different compartments at different water potentials.

Hydraulic conductivities of the ploughed layer and the plough pan were found statistically similar between –1 and –0.2 kPa, but significantly less (5 % level) than that of the undisturbed soil, itself being less than that of the seed bed. No differences of conductivity could be detected at saturation due to a high within-compartment variability. Significant differences at all potentials (including saturation) were found between soil below and between the wheel tracks.

Such information were useful for improving water transport modelling in cultivated field plots. As an example, we present some exploratory results on water transport simulated with Hydrus 2D.

Key words: Hydraulic conductivity, tillage, soil structure, compartmentalisation

Using pedotransfer functions and DEM data to predict soil hydraulic properties in different soil-landscape units

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Abstract

The recent trend toward large-scale distributed-process modeling has generated a pressing need for detailed information on spatial distribution of input data, especially of those parameters describing the hydrologic behavior of soils. It is often the case that soil hydraulic properties, namely the water retention, $\theta(h)$, and hydraulic conductivity, $K(\theta)$, functions, are not available from standard sources or are not in a suitable format for computer processing. Moreover, a good assessment of soil hydraulic properties and their inherent spatial variability plays a crucial role as this information may influence the simulated water fluxes even significantly.

To carry out the soil hydraulic characterization in a cost-effective way, pedotransfer functions (PTFs) are being increasingly used to estimate soil hydraulic properties from easily measurable or already available soil data. On the other hand, several studies have shown that the distribution of soil properties can be explained, to a certain extent, by landscape variables. Therefore, digital terrain analysis can provide a systematic basis for deriving topographic attributes and using them to improve the prediction of key soil hydraulic parameters. Up to now PTFs usually consider as input information only soil physical and chemical variables measured at the same spatial scale (pedon scale) of the dependent soil hydraulic variables. A natural step forward is to take, in addition to variables, such as, bulk density, texture, organic matter content, etc., also landscape variables into account. Therefore, a major objective of this study has been to examine the possibility to improve the performances of published PTFs by including information obtained from terrain attributes, such as elevation, slope, aspect, and wetness index. This additional information can be easily extracted from a digital elevation model (DEM) of the study area.

Evaluations were carried using soil data sampled in the "Fiumarella di Corleto" catchment (Basilicata, southern Italy). Equally spaced sampling locations were established in two transects running along different soil-landscape units. At each location, soil cores were collected from the uppermost soil horizon and subject to laboratory measurements. Some of the most widespread PTFs were tested and their original predictions were adjusted by adding landscape information. Multivariate analyses were used for this purpose, whereas statistical indicators of goodness-of-fit helped in evaluating the effectiveness of the proposed procedure. The results show a substantial improvement of prediction performances when terrain attributes are used as additional information in a pedotransfer rule. In particular, and more importantly for certain applications at catchment scale, the modified PTFs generate unbiased predictions. Another important issue of this study is also the attempt to highlight the different role that the terrain attributes play in the definition of soil hydraulic properties in different soil-landscape units of the "Fiumarella di Corleto" catchment.

Key words: soil hydraulic properties, pedotransfer function, Digital Elevation Model, terrain analysis, spatial variability.

Influence of soil loosening on water and solute infiltration in a heavy-clay soil of Southern Romania

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Abstract

Heavy-clay soils containing 45-60 % clay are representative for the southern and western parts of Romania. Most of them develop intense swell-shrink processes and show surface-gleyed characteristics, their matrix possessing a very low hydraulic conductivity.

One year after performing a drainage system and deep loosening perpendicularly over the plastic drains, irrigation water was applied for a 3-day period over the soil by sprinkling, using a 10-mm/h-rain intensity within a 10-our time daily. Five days after the initial water application another 140 mm of water was applied, and in the 7th day an 80 mm solution containing complex chemical (NPK) nutrients was also spread over the soil plots in order to find out the characteristic ways of the liquid-nutrient movement in such soils when wet.

Deep loosening modified soil bulk density (BD) that increased with distance from the deep loosening tracks where minimum BD values occurred. BD showed its maximum at the mid-distance between the tracks due to the compaction effect induced by the deep loosening device used. As a consequence, soil hydraulic properties were also changed, by increasing the soil hydraulic conductivity and the soil water flux. The deep loosening tracks are a very active macro pore space and manifest, for wet soils, a similar role as the cracks for dry soils.

Drain flow discharge and volume in the plastic drains as well as soil water flux decreased curvilinearly with time, from the satiation state when they reached the maximum value (about 6 mm/h discharge), to their stop a few days later. Internal drainage became negligible 3-4 days after ceasing of water application on the field at the soil satiation state. After the first week of relatively intense internal drainage, a soil water amount of about 87 mm was lost through leaching. Soil water flux internally drained, that included also the plastic-drain discharge, was as much as 8 mm/h and decreased to about 3.5-4.0 mm/h within a four-day time.

Plastic-tube drainage systems associated with deep loosening made perpendicularly on the drainage tubes that were installed at a 0.8 m depth and 10-20 m spacing, were an efficacious measure of controlling the excess rainfall water in such heavy-clay soils when deep loosening was periodically re-made.

Generally, the nutrient solution front stayed behind the waterfront and moved preferentially through the soil. Thus, the nutrient solution penetration front arrived at the 45 cm depth in the soil matrix during the first day after solution application, and at about 60 cm near the deep loosening track. Even one week after solution application, its redistribution still maintained preferentially. It indicated that certain amounts of fertilizers could thus be lost by leaching, together with the excess water.

Related to the priorities for the hydro-amelioration measures needed to control soil water it could be stated that the first priority is to prevent excess rainfall in these soils during spring, while the second priority is to irrigate them during summertime.

Key words: leaching, internal drainage, soil water flux

Field measurements of hydraulic characteristics in old terraced land

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Abstract

The construction of the terraces in Tuscany are known since the end of the XVIII century. In the last century to get more cultivable areas, the extension of terraced lands increased enormously influencing the hydro-sedimentological response.
Nowadays the abandonment of the agriculture or the lack of land maintenance has resulted in subsequent and progressive degradation of terraces and drain ditches with the consequence of changes in runoff and erosion processes.
In this paper field measurements of soil hydraulic parameters in terraced land of small watersheds in Tuscany (Italy), selected as representative of recently abandoned land use, are presented.
Field instruments and experimentation methodology for soil infiltration rate in-situ measurements and soil sampling are described.
A significant number of samples were collected according to a grid cell to cover different areas. Data statistic analysis has been carried out for validation and for investigate the relationships between different parameters.
The spatial variability have been evaluated in order to optimize the grid scale for the local measurements and to take into account the influence due to the presence and conservation level of terraces.
Finally a thematic map representation for each parameter investigated has been built up.

Key words: terraced land, hydraulic soil parameters, spatial variability

Development of water control for tropical wetland agriculture

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ABSTRACT

Groundwater control in agriculture land converted from tropical peatland is very crucial, not only for attaining optimum production but also for preventing soil degradation. Commonly, peatsoil tends to subside when ground water level goes down below a considerable threshold point for a periode of time. Controlling groundwater level with conventional way such as gravitation method has been proved ineffective since, in most cases, groundwater level changes abruptly with time as directly affected by tidal and rainwater. This research was aimed at applying a real-time water control system in providing sufficient water for plant growth and at the same time preventing soil subsidence. Experimental studies were carried out in a small plot of 10 x 10 m^2 in tidal-influenced wetland agricultural area. Groundwater level in the plot was measured continuously using pressure transducer, and this information was transferred electronically to a microcomputer to be analysed by means of Fuzzy Logic Algorithm. Output from the computer was sent to an actuator that would command whether drainage or irrigation pump should be ON for a definitive time. The results showed that groundwater level inside the plot could be maintained around the set point level even though the actual groundwater level changed consiredably with time.

Key words: tropical peat soil, wetland agriculture, water control

Irrigation with brackish water: effects on soil strength of a fine-textured soil

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Abstract

The penetrometer is the most widely used instrument for assessing in situ soil strength that is one of most important factors affecting root growth and consequently crop productivity.
During a two-year period (1999-2000), soil penetration resistance was measured with a cone penetrometer in order to evaluate the effects of saline water irrigations on soil strength.
This study was carried out in Southern Italy, in a coastal area of Basilicata region (Metaponto: lat. 40° 24' N and long. 16° 48' E). The soil is classified as a Typic Epiaquerts, similar to those formed on silty-clay and clay lagoon sediments of the Oleocene that are present over large portions of the alluvial basin between the Basento and Bradano rivers.
The penetration resistance (cone index) was measured to a depth of 52.5 cm at 3.5-cm intervals on three adjacent plots submitted, since 1998, to different crop irrigation treatments: fresh (F: 1 dS m^{-1}), saline (S: 4 dS m^{-1}) and fresh/saline water (FS). We carried out three surveys in the first year of maize cultivation and two surveys in the following year of sugar beet cultivation. Each survey consisted of 54 penetrometer measurements on a 1.5 m by 2 m grid.
In order to treat the spatio-temporal variability of soil impedance, a multivariate approach is proposed, where the set of t sampled times is treated as a realisation of t inter-correlated random functions. The estimation of the property of interest involved fitting an anisotropic linear model of coregionalization to the t(t+1)/2 simple and cross-variograms consisting of two spatial structures: an isotropic structure on the horizontal plane and another one in the direction perpendicular to the surface.
The variography revealed a high temporal correlation between the soil strength measured at different times, which proved that the soil profile structure was conservative.
For each survey, a three-dimensional map was produced interpolating the data by cokriging. The visual comparison between such maps revealed a temporal variability but the soil structure, along the vertical profile, was not significantly altered by the effects due to saline irrigations.

Key words: Soil strength, Penetrometer, Irrigation, Saline water

Water interception capacity of forest litter

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Abstract

Although litter is worldwide known to be the major source of organic matter for forest soils and its hydrologic role is enough clear, it has been found that experimental studies on its hydrologic characteristics are seldom available.
The present work deals with the estimation of the spatial variability of the interception capacity of the forest litter through the analysis of undisturbed samples of forest floor taken under different forest canopies in Tuscany.
The interception capacity of the forest floor in the study area was estimated using a combination of field observations and laboratory measurements. Due to the spatial variability of the amount of the forest floor litter, a large number of random samples were collected to give an accurate assessment. A grid cell was selected to cover the study area and the location of the sampling point within each cell was selected by an x and y random number system.
Once the sampling point was located, a steel sampling cylinder of 32 cm diameter opportunely realized for the experimentation was placed and tapped in with a hammer in order to retain the forest floor material within the sampler. The surrounding forest floor material was scraped away from the template and then undercut in the mineral soil with a saw. The block then was transferred out of the sampler into a container for being analyzed through laboratory tests. A system of artificial rain was applied to undisturbed samples of the forest floor to be wet. To measure water storage capacity, the samples were weighed before and after being subjected to simulated rainfall.
The experimental procedure involved three major activities: 1) realization of thematic maps through a GIS containing different information of the forest floor obtained through field observations; 2) laboratory experiments on the forest floor samples to get the water storage capacity values; 3) extrapolation of the results at basin scale.
Preliminary results are discussed in order to quantify the amount of water that can be retained on the forest floor. Such an amount is a fundamental input value of any hydrological balance.

Key words: forest litter, water interception, rainfall simulation

Changes in soil physico-chemical properties of an alluvial soil under different forest tree species

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Abstract

Vegetative cover plays an important role in accumulation of organic matter and microbial activities favourable for soil physical condition. An evaluation of soil properties under different tree covers is an important area of research to understand the impact of trees on soil. In plantation, cycling of nutrients is an important aspect as considerable amount of nutrients are returned through litter fall and become available for recycling. In the present study, the effect of different tree species on soil physico-chemical properties was studied on a deep sandy loam (Typic camborthid) soil at University Research Farm, Hisar. The Hisar district of Haryana State is located between 28°59' to 20°49' N latitude and 75°11' to 76°18' E longitude, with an elevation of 215m above mean sea level. On an average annual rainfall varies from 353to 447 mm during monsoon season (July-August). Annual temperature ranges between 16.8 to 34.4 °C. For the present investigation, eight-year-old plantation for Eucalyptus (*Eucalyptus tereticornis*), Poplar (*Populus deltoides*), Shisham (*Dalbergia sissoo*), Sirish (*Albizzea lebbeck*) and Khejri (*Prosopis cineraria*) growing on normal cultivated field was selected. The undisturbed soil core samples were collected depth-wise from these pedons and analyzed for organic matter content, particle size distribution, bulk density and hydraulic conductivity. Soil moisture depletion was estimated at 15 days intervals. Infiltration rate was determined by close top infiltrometers *in situ*. These parameters of tree planted sites were compared with adjoining normal cultivated field.

Among the tree species Khejri was found to increase the maximum amount of organic carbon in soil followed by Shisham, Sirish, Poplar and Eucalyptus. All the tree species reduced the soil bulk density at different layers. The reduction in bulk density was more in Eucalyptus followed by Khejri, Poplar, Shisham and Sirish, plantation. Porosity of the cultivated field increased with plantation of forest tree species. The maximum increase in porosity was noted with Eucalyptus followed by Poplar, Khejri, Sirish and Shisham. The infiltration rate increased by 13, 8, 6, 5 and 3 times with plantation of Eucalyptus, Poplar, Khejri, Sirish and Shisham over normal cultivated field, respectively. The saturated hydraulic conductivity of normal cultivated field increased with plantation of forest tree species. The maximum increase in saturated hydraulic conductivity was observed in Eucalyptus followed by Poplar, Khejri, Sirish and Shisham. The moisture depletion rate in 45 days after a rainfall event was found to be maximum under the plantation of Eucalyptus (0.34 cm d^{-1}) followed by Poplar (0.29 cm d^{-1}), Shisham (0.25 cm d^{-1}), Sirish (0.21 cm d^{-1}) and Khejri (0.18 cm d^{-1}) whereas the corresponding value for adjoining normal cultivated field was 0.10 cm d^{-1}.

Key words: Tree plantation, physical properties, moisture depletion.

Field/lab measured hydraulic properties in three volcanic soil profiles

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Abstract

Predictions of water and solute transport in soils are traditionally based on the Richards equation describing variably-saturated water flow. Especially important in variably saturated flow studies are the unsaturated soil hydraulic properties, i.e., the soil water retention and the hydraulic conductivity curves. Significant efforts are made in order to measure these hydraulic functions both in the laboratory and in the field and several methods are nowadays available.

A number of publications give detailed descriptions and comparison of laboratory and field methods and also provide a system of selection criteria. In comparison to field methods, laboratory methods result particularly attractive because of the direct availability of measuring devices and other facilities as well as good control of the measuring procedure. However, part of the differences frequently observed between retention and hydraulic conductivity as obtained with field and laboratory methods are explained by invoking, depending on the circumstances, i) the different observation scale; ii) the different measurement scale; iii) the spatial variability of the investigated properties; iv) the theoretical bases of the methods and their experimental shortcomings. The analyzed methods are characterized by any of these points, as well as by the particular experimental test conditions, including any procedures adopted to impose specific initial and boundary conditions to the flow field. Nevertheless, the implications of the latter on the shape of hydraulic functions are generally just partially discussed.

To the contrary, based on the comparison of measured field and lab hydraulic properties, this paper aims to identify the effective physical mechanism mainly involved in determining the observed differences. We examined the performance of the internal drainage method in the field as compared to the laboratory evaporation method carried out on soil cores. Accordingly, a pattern based on the hysteretic behavior of soil hydraulic functions is proposed in which lab/field curves are interpreted as belonging to the same hysteresis cycle so that the specific experimental test conditions are decisive for determining the observed differences between field and laboratory hydraulic functions. Preliminarily, conceptual considerations on the efficacy of the soil core volumes to represent soil properties at the pedon scale is also provided. The final aim of the work is to identify the only variables actually involved in determining the differences, allowing for them to be systematically considered in the comparison.

Influence on runoff at watershed scale of hystorical terracement and forest litter

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Abstract

Mediterranean mountain areas were intensively used in the last century for cultivation by means of construction of terraces realized by stone walls and drain ditches.
The aim of the present work is to investigate the hydrological processes related with the presence of terraced areas in small basins in Tuscany (Italy), selected as representative of recently abandoned land use (Chestnut crops).
The construction of terraces across the slope for agricultural purposes induces relevant modifications of the local slopes and land use. In fact, a terraced slope shows different characteristics from another one covered by natural vegetation.
In order to analyze the influence on runoff generation at watershed scale, distributed thematic maps of the localization of the terraced areas and of the related parameters were realized using a GIS and used as input to a distributed hydrologic model.
An investigation about the intensification of terraces in the watersheds under study has been carried out digitalizing ancient maps.
The hydrologic modeling at watershed scale is based on some field measurements of soil and litter hydraulic parameters and on topographic surveys.
Moreover we noted that a slope map derived from available DTM was not able to represent the discontinuities of a terraced slope. For such a purpose, it is proposed to modify locally the slopes of terraced areas through the help of field surveys with a suitable algorithm.
Simulation runs are made in order to compare the different hydrologic response on terraced and non-terraced areas.
Finally, consequences on slope stability caused by the abandonment of terraces are discussed.

Key words: terraced land, runoff generation, watershed modeling

Modeling soil water-retention curves by means Van Genuchten and Shirazi-Boersma parameters estimated from grain-size distribution

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Abstract

In defining the hydraulic properties of non-saturated porous media, the field and laboratori methodologies that follow the instantaneous profile method have proved capable of correct hydraulic characterization. However,they require complex, costly equipment and great accuracy in measuring water content θ and potential h.
Further simplication may arise from the possibility of deducing $\theta(h)$ and $K(\theta)$ functions from several soil physical properties that are easy to determine.
Various empirical models have been proposed in the literature which link, by means of multiple-regression techniques, water content foe an assigned potential value to various soil parameters: texture,organic matter content, bulk density.
Perinent to the above approach are also several studies that indicate additional promise in relating the cumulative size distribution to the $\theta(h)$ curve.
In the light of the pratical application of deducing soil water retention and hydraulic conductivity relations from simply determined physical properties, due consideration was given to physical-empirical models in the literature based on the transformation of a granulometric curve in to a retention curve.
In particular forecasting potentials were evaluated with regard to two models propsed respectively by Jonasson and Shirazi-Boersma relative to 30 soils occurring in Southern Italy.
Basis for the first method is a transformation of grain size to the soil water pressure head, similar to the Arya and Paris method, but expressed in a more direct, analytical way.
The tranformation is combined with a simple procedure for estimating the van Genuchten hydraulic parameters. The methodology yields relatively simple analytical expressions for the parameters α and n values in the van Genuchten equation.
For all soils the parameters in the van Genuchten equation were obtained by non linear least squares.
The basic assumptions and prerequisites of the method are presented, as well as its limitations.
The results of the elaborations for all the soil samples, together with the experimental calculations, allowed to represent $\theta(h)$ graphically. The $\theta(h)$ trend relative to only a few soil samples, for the sake of brevity, may be deduced from graphics, in which the curves obtained with the two models are compared.
For the case study, the achieved accuracy is in agreement with the results reported in the literature.

Scale-dependency of Pedo-Transfer-Functions in the estimation of soil hydraulic characteristics: a case study.

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Abstract

The hydraulic characterization of large areas can be carried out in a cost-effective way by using pedotransfer functions (PTFs). These simplified methodology are being increasingly used to estimate soil hydraulic parameters from easily measurable or already available soil data. It is well established that every soil properties show peculiar spatial variability. An important issue arising when carrying out regional scale hydraulic characterization is linked to the need for an accurate description of the spatial structure of the variables investigated. For this reason it's important to define the accuracy of a simplified methodology as respect the prediction of the spatial variability of key soil variables. Primary scope of this study is to investigate if the physico-empirical method proposed by Arya and Paris for the estimation of soil water retention is reliable to preserve spatial variability of the soil water retention curve's parameters.
A modification of the Arya-Paris (A-P) model proposed by Basile and D'Urso has been implemented to consider the relation between the spatial structure of the parameters involved in A-P model calibration and the spatial structure of the water retention curve parameters. Evaluations were carried using soil data sampled in the Sinistra Sele irrigation district (South Italy). Equally spaced sampling locations were established along a transect across two soil units. At each location two undisturbed soil samples and bulk soil were collected from the Ap and Bw soil horizons. On bulk soil samples particle size distribution curves were determined; bulk density, soil water retention curve and saturated hydraulic conductivity were measured on each soil cores. The soil water retention curves on soil cores were used to identify a calibration curve $\alpha(h)$ between the empirical parameter α used in the A-P model and the soil water pressure head h. Previous studies carried out on randomly distributed locations evidenced that this calibration function reflects the influence of internal soil structure on the soil water retention characteristic.
This improvement to the A-P model is analyzed in this study in relation to:
1) regular sampling along a transect to examine the scale and spacing dependency of the calibration adopted;
2) accuracy of estimation at small scale surveys;
3) similarity of calibration curves for samples collected in the same mapping unit.

This latter aspect would confirm the existence of a physical meaning for the calibration function $\alpha(h)$.
By the results of this kind of analysis it has been possible to highlight the clustering between the distribution of calibration parameters as respect soil unit or soil class. In this way for each homogeneous group a unique calibration relation can be proposed to derive an improved estimate of the soil water retention curve, by means of fewer direct measurements operations in some representative sites.

Key words: soil hydraulic properties, pedotransfer function, spatial variability

Soil hydraulic properties of volcanic soils of Terceira, Azores

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Abstract

The islands of Azores are of recent volcanic origin and their soils have characteristics peculiar to their origin. Several other areas in the world, inclusive in Europe, have similar soils but their hydraulic properties and respective methods of observation still are less known. Aiming at environmental modelling of land use impacts, as described in a companion paper to this Conference, two experimental sites have been selected for *in situ* observations and sampling for laboratory analysis. Soil use in one site is grassland, on the second is a rotation of five years grass and one year forage corn. The laboratory methods used for the water retention curve were the sand box (SB), the sand and cauline box (S+CB), the pressure membrane (PM) and the evaporation method (EV). For the hydraulics conductivity curve, the laboratory methods were the crust method (CM), the hot air method (HA) and the constant increment method for estimating the capillary diffusivity (CID). Observations *in situ* were performed in a soil monolith using first the free drainage method and, later, the null flux plan method. The presence of halofanes in the soil gives poor accuracy to determinations with the SB and S+CB methods, largely overestimating $\theta(h)$, while the EV method produced results similar to those from the monolith for the low suctions ($pF<2.8$). The PM method produced also appropriate results for high suctions. The HA method proved inappropriate for these soils, producing high overestimation of $K(h)$ values. The CM and the (CID) methods have shown acceptable accuracy for low suctions ($pF<2.1$) but not for higher suctions.
The $\theta(h)$ curves are described by the van Genuchten function modified by Smith (VG-S), and the $K(h)$ curves are parameterised with the Brooks and Corey function modified by Smith (BC-S) as to make compatible the parameters in both curves. The parameters were iteratively adjusted with help of model OPUS, as described in the companion paper[4], when comparing simulated with observed soil water content in both sites.
This paper describes the characterization of the soil hydraulic properties for all soil layers in both sites, analyses the results obtained with the laboratory methods compared with those obtained *in situ*, and presents the $\theta(h)$ and $K(h)$ curves as described by the VG-S and BC-S functions. Finally, comments on the peculiarities of the observed volcanic soils properties are presented

Environmental sustainability of hydrology projects in the North of Tunisia

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Abstract

In the Mediterranean area Tunisia is an example, where the water resources for agricultural use are rather limited, and the extension of irrigated agriculture is mainly possible by using saline water. For this reason, extensive field research was already carried out in the 1960's, within the framework of UNESCO project.
Water resources in Tunisia are now estimated at 2.7 million cubic meters. Agriculture entirely depends on irrigation from the Medjerda River. It is the only permanent flowing river and carries one million cubic meter of surface water. However, according to the analyses these waters are more or less saline. In the lower Medjerda Valley, the irrigation water is moderately saline (EC = 2,8 mS/cm, SAR = 6,2), thus, at Cherfech the salinity content of the Medjerda water varies during the year from 1.7 to 3.5 g/l.
The total area of irrigated perimeters in Tunisia is about 350.000 hectares, in which 30.000 hectares are affected by salinity (12%). The salinity is found in the whole territory, but particularly in the North and in the South of the country.
The use of saline water for irrigation is subject of increasing interest because of the augmenting water requirements for irrigation and the competition between human, industrial and agricultural use; and also because of the pressure for the disposal of drainage water through reuse.
Subsurface drainage has been tried out in an experimental research field station (Cherfech) in the Northern part of Tunisia. Tile drains have been installed in manually excavated trenches in silty clay loam soils, with a shallow ground water table and which is irrigated by saline water.
Soil salinity in the Cherfech experimental station is a result of climatic conditions, original soil chemistry, land over use, irrigation practices, and the shallow depth of the water table.
The re-use of drainage water is practiced worldwide. In the North of Tunisia, farmers re-use drainage water by pumping it for irrigation directly from the drains.
The purpose of this study is to assess the impact that drainage projects have on their surroundings (i.e on the environment) and to introduce methods to assess these impacts.

Key words: GIS, OMS, subsurface drainage, model

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Infiltration measurements for determining effects of land use change on soil hydraulic properties in Indonesia

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Abstract

Due to population growth and increase in food demand, large areas of tropical forest and coconut plantation in Indonesia have been converted to intensively cultivated agricultural fields. Soil structural changes, erosion, and nutrient losses due to cultivation have been observed. However, changes in hydraulic properties are not quantitatively known for recently converted field soils. The objective of this study was to analyse changes and spatial structures of hydraulic properties for different land uses. Infiltration was measured along two 100 meter transects (2 m intervals) using the tension infiltrometer (TI), the pressure infiltrometer (PI), and the Guelph Permeameter (GP). The clay soil transect was located in a coconut plantation and consisted of a 50 m no-till (NTC) and a 50 m freshly tilled (FTC) part. The loamy clay transect was half located in a secondary tropical forest (STF) and in an adjacent recently cleared conventionally tilled soil (CTS). At each transect, infiltration was measured at the soil surface using TI and PI, and in 20 cm depth using GP. Saturated hydraulic conductivity, K_s, was calculated using multiple-head (TI, PI) and one-head analysis (GP). At the soil surface, the hydraulic conductivities were spatially more variable for NTC (K_s = 1 to 1,000 cm/d) than for FTC (K_s = 10 to 1,000 cm/d), and the highest values for STF (K_s = 200 to 20,000 cm/d) were twice that of CTS. In 20 cm depth, K_s-differences between NTC (K_s = 0.1 to 500 cm/d) and FTC (K_s = 0.1 to 5,000 cm/d) were larger and between STF (K_s = 500 to 3,000 cm/d) and CTS (K_s = 1 to 300 cm/d) smaller than at the surface. Hydraulic conductivity, K_s, decreased after changing STF into CTS, where spatial variation was especially low in 20 cm depth due to compaction. Relatively large infiltration rates at saturation for FTC were attributed to tillage-induced macroporosity and for STF to root and soil fauna channels. Relatively slow infiltration rates for CTS reflect the effect of the structural degradation of the soil surface layer. Semivariograms show relatively small spatial correlations along transects. Tree distance and soil tillage seem to have most influence on the spatial structure of K_s. Since the NTC practise on clayey soils showed relatively low infiltration rates, careful soil cultivation may here increase the infiltration and thereby reducing soil erosion. Agro-forestry systems, e.g. annual combined with perennial crops, may probably be more effective in reducing erosion.

Key words: infiltration, hydraulic conductivity, land use change, tropical forest, coconut plantation

Effect of loading time on soil strength and consequences for the hydraulic processes and properties

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Abstract:

The discussion about the time dependence of stress application as well as the effect of hydraulic fluxes on soil strength as a function of time of loading is very often based on mainly assumptions but the amount of profound data is negligibly small.
Thus, these questions have been analysed both by homogenized and some undisturbed soil samples which were loaded in between 2 and 10 minutes. The results obtained support the theory, that depending on the hydraulic properties of the material, the effects of internal pore functioning strength govern to a great extent the compressibility and can be also used to predict the soil strength and the effects on flux processes.
During the lecture, the basic theoretical ideas as well as the corresponding data about time dependent precompression stresses and the reasons which can be explained by hydraulic analysis and shear data will be presented and the consequences for land use and the agricultural engineering industry discussed.

Irrigation management in shallow ground water resources for sustainable production of wheat and brassica in semi-arid condition

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Abstract

Introduction of irrigation in arid and semi-arid regions of world has resulted in rise of ground water table. India is no exception to it. Most of northern part of India, comprising Punjab, Haryana, Uttar Pradesh and Rajasthan is facing problem of rising water table. Unscientific use of irrigation water under shallow water table condition in the absence of natural drainage results into water logging and secondary salinization. The rise in water table in canal irrigated areas can be minimized through proper scheduling of irrigation to field crops. The present study was, therefore, conducted to determine the irrigation requirements of two important crops of the region, viz.: wheat (WH-283) and brassica (RH-30) under shallow water table (<2.0 m) condition at Hisar during winter seasons of 1992-93 to 1995-96. The soil of the experimental field was a deep sandy loam (Typic camborthid), low in N, medium in P and rich in K. Water table depth fluctuated between 0.8 to 1.7 m. There were five levels of post sowing irrigation (0, 1, 2, 3 and 5) in wheat and three (0, 1 and 2 in brassica.

The wheat and brassica were sown in the first fortnight of November. Water table depth during crop growth season was recorded using piezometers. The profile soil moisture content was monitored at fortnight interval from sowing to harvesting. The evapotranspiration (ET) was estimated using universal water balance equation. Capillary contribution from ground water to crop root zone was computed using Darcy's low. The capillary conductivity (K_θ) was estimated using the method of Campbell (1974). Two post sowing irrigation resulted in significantly higher yield of wheat where as only one post sowing irrigation gave significantly higher yield of brassica. Wheat grain yield up to 2500 kg ha^{-1} was obtained even without post sowing irrigation. Capillary contribution of ground water decreased with increase in post sowing irrigation levels. Under no post sowing irrigation condition, the average seasonal capillary contribution to wheat root-zone was equal to 0.135×10^{-10} m s^{-1} which reduced to 0.120×10^{-10}, 0.115×10^{-10}, 0.110×10^{-10}, and 0.105×10^{-10} m s^{-1} in 1, 2, 3 and 5 post sowing irrigation. About 55, 50, 40, 35 and 25 per cent of total ET demand of wheat and 50, 40 and 30 per cent of brassica was met through ground water contribution under 0, 1, 2, 3 and 5, and 0, 1 and 2 post sowing irrigation level, respectively.

Key words: Irrigation requirement, evapotranspiration, capillary conductivity, wheat, brassica.

A bootstrap analysis of the variability of parameters of the relation between soil water content and unsaturated hydraulic conductivity determined by the instantaneous profile method

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Abstract

Hydraulic conductivity is the most important soil property to be known when studying water movement in soils. Water content (□) of agricultural soils is almost always below saturation and the relation between hydraulic conductivity and water content should thus be known when studying water movement in these soils. A frequently used field method to obtain this relation is the instantaneous profile method and its results are often expressed as an exponential equation, e.g. $K(□) = K^*.\exp(□.□)$ in which K^* is the hypothetical conductivity of the completely dry soil and □ is a fitting paramenter. High variability in the parameters obtained for this equation, even within relatively small areas, have been reported frequently. In this study, we aimed to evaluate the variability of these parameters on a udic oxisol in São Paulo State, Brazil.

TDR-probes (MoisterePoint™, type "H", with sensors at 0-0.15, 0.15-0.30, 0.30-0.45, 0.45-0.60 and 0.60-0.75 m depth) were installed every 1 meter along a 50 m transect alowing soil moisture monitoring. Together with these, tensiometers were installed at the same depths at a distance of about 0.1 m of each TDR probe. The area was sprinkler irrigated during 5 days until the soil reached a high water content and downward water flow. Soil surface was then covered with a plastic sheet and water content and matric potential were monitored: a first reading was made at time zero, a second 6 hours later, a third 24 hours later. After that, readings were made every 2 or 3 days until completing 25 readings during 57 days. Data were processed using a computerized analysis procedure and the variability of the obtained parameters K^* and □ are being calculated using the bootstrap analysis technique in order to relate variabilities to the number of observation points.

Results will allow to choose the number of observation points necessary to obtain a desired variability or precision of unsaturated hydraulic conductivity estimates in future determinations and also give an idea of the reliability of reported measurements, usually with a small number of replicates.

Key words: bootstrap, hydraulic conductivity, spatial variability.

ADHYDRA : a user-friendly simulator of soil moisture time variability.

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DEIAFA – Idraulica Agraria, Università degli Studi di Torino

Abstact:

ADHYDRA is a code that implements the multidimensional Richards equation numerical solution of SWMS2D (Simunek et al., 1994). It possesses a simplified user interface that allows simulating the presence of root apparatus and of irrigation, by drawing their shapes with a Computer Aided Design interface. It is possible to update continuously a soil and a plant data bases, each containing the respective hydraulic properties. The meteorological data are possible to be copied directly from the data files provided by the meteorological services. The more original feature is in the possibility to simulate different methods of irrigation, based either on time or soil moisture/matrix tension scheduling. Also, it allows simulating the effect on water status due to the time variation of soil properties.
This work was funded by EU FAIR1 PL95 0681.

Key words: model, unsaturated zone, hydrology.

Monitoring of soil moisture on the basis of remote sensing data and geoinformation system

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Abstract

Realization of modern conception of agriculture is connected with the use of remote sensing data and GIS technology. Moreover contemporary agricultural activity is impossible without geo-located data about soil water regime on agricultural lands. With this signification of monitoring of soil moisture on the basis of remote sensing data and geoinformation system is difficult to overestimate.

Monitoring of soil moisture is based on a principally new algorithm (procedure) for determination of the water content in a soil from brightness temperature measurements in microwave range. This algorithm implies the preliminary laboratory microwave measurements of the soil basic electromagnetic parameters and the use of the original methodology for extracting the soil wetness from microwave two frequency airborne data. High accuracy (10% and less) of the algorithms is the most essential difference from the others.

The designed remote sensing method is integrated into intelligent GIS. Also in the GIS several applications of fuzzy set theory are implemented. During the last few years, considerable study has been given to development of fuzzy set theory. This theory is very useful when there is insufficient data and it is impossible to use methods based on probabilistic theory. Recent advances in the application of fuzzy set theory coupled with GIS, create the new opportunity for building prototype decision support systems.

Soil water dynamics in a Brazilian infiltration terrace

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Abstract

An important soil conservation technique is the construction of level infiltration terraces, aiming the reduction of runoff. Dimensions and distances between such terraces are often established based on empirical relations that do not take into consideration hydrological principles. Therefore, terrace dimensions are frequently inadequate. A too big terrace leads to unnecessary costs, while a too small terrace will be insufficient during a heavy rainstorm event. When studying the hydrology of an infiltration terrace, degradation of the soil in the interception canal due to compaction and deposition of eroded material should be considered. Therefore, it is to be expected that the hydrology and the lifetime of such a terrace will depend on the erosion and infiltration capacity of the area it receives runoff from. In this study, we aimed to evaluate the soil water movement below the infiltration canals of four treatments receiving runoff form areas with different soil covers: bare soil, densely grass-vegetated soil, maize (conventional tillage) and maize (no-tillage) on a udic oxisol in São Paulo State, Brazil, with a slope of about 0.07 m m^{-1}.
In each treatment, TDR-probes (Trase^{TM} buriable sensors) were installed at three spots (distance between them 7 m) in the middle of the canal at depths of 0.05, 0.10, 0.20, 0.40, 0.60 and 0.80 m. At the same depths, undisturbed soil samples were taken for soil water retention determination. TDR-readings of each sensor were made automatically every 30 minutes while rainfall intensities were monitored using an automatic rainfall gauge. At the end of every erosive rainfall event, deposition of eroded material in the canals was measured. During the dry season (June-July), unsaturated hydraulic conductivity was determined at each spot using the instantaneous profile method.
Results allowed to verify that different erosion rates within the treatments resulted in different infiltration patterns. Deposition of eroded material decreased in the order bare soil, conventional maize, no-tillage maize and grass. Consequently, infiltration in the bare soil canal used to be slower, indicating that this kind of superficial degradation of infiltration canals should be taken into consideration when determining terrace dimensions.

Key words: level terrace, hydraulic conductivity, infiltration.

Hydraulic characterization of a lowland soil under different management systems

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Abstract

The study of soil water dynamics and its relations with the soil physical properties has deserved special attention in lowland soils because these soils, with hydromorphic characteristics, present some troubles in their use, mainly when under drought crop conditions. Among the main problems there are: low soil water storage, low hydraulic conductivity and low water infiltration rate. Assuming that different management systems change, in different ways, the soil physical properties, this work was carried out with the objective of determining some hydraulic parameters of a lowland soil from the State of Rio Grande do Sul (Brazil) using the following cropping systems: TCS – traditional cropping system (one year with rice crop using conventional soil preparation followed by two years of fallow), CCS – continuous cropping system with rice, using conventional soil preparation and weeds control with herbicide, CRS – crop rotation system (rice x soybean x maize) using conventional soil preparation, NT – no tillage in a succession of rye-grass in the winter and rice in the summer, NS – natural system (soil under natural conditions = control). The hydraulic parameters investigated were soil hydraulic conductivity as a function of soil water tension using disc permeameter (the tensions used were 0.00, 0.25, 0.50 and 1.00 kPa) and soil water retention curve using undisturbed soil samples in porous plate funnels and Richards pressure chambers. According to the results, the following could be concluded: a) even though there were no statistical differences (Tukey at 5%) among treatments, at the tension of 0 kPa, the soil under NS presented the highest value of hydraulic conductivity, 100% higher than the value of the soil under TCS; at the same tension, the values for the soil under CRS and NT were similar to that of NS treatment; b) the surface soil layer of 0 – 0.10 m under NS presented the highest value of soil available water and the soil under CRS, the least; c) the upper limit (soil water content at 10.2 kPa), used to calculated available water, cannot be applied to the studied soil because it does not permit the minimum necessary aeration condition, that is, aeration porosity of 10%.

Water flow in soils with pitcher irrigation

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Abstract

The objective of this research was to study a performance of a pitcher irrigation as indicated by the capability of the pitcher to release water and by the moisture profile of the surrounding soil. Experimental study was conducted in laboratory with 2 (two) types of soils, i.e., Silty Clay and Sand in a transparant soil box. Numerical study was also undertaken to estimate the water flow in the soil using 2-D Finite Element Method. The pitcher was formed like a bottle with the following dimensions: body diamater of 14 cm, neck diameter of 7 cm, and height of 14 cm. The permeability of the pitcher wall was in the order of 10^{-6} cm/s. During the experiment, the water level inside the pitcher was maintained constant by means of a Mariotte Tube. The experimental results showed that the rate of water released from the pitcher was directly influenced by the wetness of the surrounding soil in a very specific pattern. When the soil was initially dried, the rate of the water flow increased but then decreased very slowly approaching to almost zero rate when the closer soil was becoming wet but not fully saturated. At that condition, the wetting front was limited to a radii of 9~20 cm and depths of 22~25 cm. The numerical solution considerably conformed to the experimental results and was used to figure out the water flow for different depths of pitcher placement in the soils.

Key words: pitcher irrigation, water flow in soil, soil moisture profile.

Desalinization and salinization of coastal clay soil with and without subsurface drainage

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Abstract

Field experiment was conducted during 1999 and 2000 to monitor desalinization of the soil profile in the presence of subsurface drainage and its salinization when operation of the subsurface drainage system was stopped. Subsurface tile drains with spacings of 15 m in 0.4 ha and 25 m in 3.2 ha were installed at the farmers' field in 1986 and 1987, respectively, to reclaim the saline coastal clay soils. The system's performance in terms of changing physical and chemical properties of the soil and rice yield was continuously monitored for more than a decade. Field data suggested the possibility of adopting wider drain spacing and thus, subsurface drains with 35 and 55 m spacing were laid in 1997 in a 4 ha land that was salt affected and no cultivation was possible. The rice cultivation in the area with newly installed subsurface drainage system was initiated in 1998 with continuous leaching of the salts through subsurface drainage.

Estimation of salt removal via subsurface drains was done by measuring the electrical conductivity (EC) of the subsurface drainage effluent. In 1999, the lowest mean salinity of drainage effluent was found to be 3.9 dS m^{-1} in 15 m drain spacing area and the highest mean salinity of the drainage effluent was found to be 44.7 dS m^{-1} and 36.7 dS m^{-1}, respectively in the 35 and 55 m drain spacing areas which were under initial stage of reclamation. A similar trend of salinity of drainage effluent of 35 and 55 m drain spacing area was observed in 2000 but EC has reduced by over 6 dS m^{-1} in 35 m and approximately 3 dS m^{-1} in 55 m drain spacing area. In 1999, the first year of reclamation, the drains spaced at 35 and 55 m , removed 85.8 and 35.3 Mg ha^{-1} yr^{-1} total dissolved salts. The rates of removal were more than twice in case of 35 m as compared to 55 m drain spacing area.The drainage rates were found to be increased by 20 and 10% , respectively in 35 and 55 m drain spacing areas over 12 months. All these data suggest the higher pace of reclamation with 35 m drain spacing. It was concluded that coastal clay soils would be reclaimed in 3-4 and 6-7 years with 35 and 55 m drain spacings , respectively.

The soil salinity (at field saturation) of the top layer (0-30 cm) in 15 and 25 m drain spacing areas was found to be stabilized at 4 to 5 dS m^{-1} till May 1997 due the sustained operation of the subsurface drainage system. The lands with 15, 35 and 55 m drain spacing remained under irrigated rice cultivation and drainage system was operational, where as the land with 25 m drain spacing was left fallow with no crop and no irrigation. The decade old drainage system in 25 m spacing area ceased to function beyond March 1999. This treatment was imposed to monitor the salinization in the soil profile which was otherwise well reclaimed during 1987-1997. In 25 m spacing area, the soil salinity in 0-15 and 15-30 cm layers has increased approximately 8 and 5 folds, respectively in the absence of leaching and drainage. The soil moisture depletion in 0-15 and 15-30 cm varied from 1 mm d^{-1} in March and 2.5 mm d^{-1} in May. It was found that 25.2 Mg ha^{-1} salt would be added to the root zone depth in a year under an evaporative moisture depletion of 2 mm d^{-1}.

Key words: Coastal clay soil, Desalinization, Drain spacing, Salinization, Subsurfacedrainage effluent

Effects of irrigation with brackish water on soil mechanical behaviour

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Abstract

The use of brackish water for irrigation in agricultural soils is worldwide recognized as a problem increasing constantly in its severity.
The paper aims to analyze changes in mechanical behavior of agricultural soils depending on different levels of sodicity and salinity due to irrigation with brackish water. It is widely recognized that these factors can negatively influence some operational features of agricultural soils such as trafficability and workability. In particular, the presence of Na negatively affects soil quality under different aspects. In spite of that, poor are the attempts about to relate soil mechanical behavior to these characteristics. An advanced and full approach to these problems is that of considering the deformations induced on soil by applied stresses in the framework of the critical state soil mechanics theory.
The paper reports the results of laboratory tests carried out with the purpose of determining the position of the Critical State Line (CSL) depending on salinity and sodicity. The effect of soil moisture levels has also been partly investigated. Four different Italian agricultural soils were tested; they are clays and silty clays different in texture and organic matter content. Each soil was treated with solutions obtained combining different saline concentration with different levels of S.A.R., giving a range of ESP and salinity values to test. Uniaxial compression tests were performed in order to determine the Normal Compression Line (NCL) and the compaction characteristics of the soils. Compressed samples were then submitted to a shear test, after a partial drying cycle. A shear box apparatus with constant normal load was used for the CSL analysis, by detecting expansive or compressive behavior (i.e. vertical displacement on the soil sample) and the Coulomb-Mohr's yield parameters. The results give a first useful framework to understand modifications induced by sodicity-salinity in soil volumetric change in response to applied stresses. The soils have shown no appreciable modification in NCL and internal friction angle at a given moisture rate. No influence of salinity/sodicity on the NCL indicates very similar compaction susceptibility. Cohesion value turns out to increase with increasing values of ESP. The CSL moves and comes near to the NCL, indicating that the variation of critical state parameters are not prejudicial to the positive effects of tillage (volumetric expansion, porous space increase), even if it would require a greater energy input and higher deviatoric stress component (more cohesive soil, greater shear strength).

Key words: critical state soil mechanics, soil salinity, soil sodicity

Near-saturated hydraulic conductivity in a fine-textured soil measured by tension infiltrometer

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Abstract

Tension infiltrometers have been used extensively to determine unsaturated hydraulic conductivities and for quantifying the effects of macropores on infiltration processes. A standard way for estimating unsaturated hydraulic conductivities from tension infiltrometer data has been to use Wooding's analytical solution. Such an approach requires steady-state infiltration rates for two different supply pressure heads or two different disc radius. Recently, a numerical inversion method to estimate the hydraulic properties from infiltrometer cumulative infiltration data was suggested. Such a methodology was then tested on sandy-loam and loamy-sand soils. The inverse procedure combines the Levenberg-Marquardt nonlinear parameter optimisation method with a numerical solution of the asymmetric variably-saturated flow equation.

This study was carried out in Southern Italy, in a coastal area of Basilicata region (Metaponto: lat. 40° 24' N and long. 16° 48' E). During the summer 2000, some tension infiltrometer experiments were conducted on a clay soil, classified as Typic Epiaquerts. Since 1999, the field has been under a sorghum cultivation submitted to irrigations with saline (S: 4 dS m^{-1}) and no-saline (NS: 1 dS m^{-1}) water. The infiltration experiments were carried out on two plots irrigated with S and NS treatments, by using a tension infiltrometer. Hydraulic conductivities at supply pressure heads in the range from –15 cm to –1 cm were obtained using Wooding' solution. The soil water contents were measured before and after each infiltration experiment.

The objective function for parameter estimation was defined in terms of the cumulative infiltration data and final water content.

The unsaturated hydraulic conductivities, obtained with Wooding's solution, were not affected by water quality irrigation treatments. In the supply pressure head range from -15 cm to -1 cm the hydraulic conductivity increased by two orders of magnitude by suggesting the presence of preferential flow phenomenon near saturation.

Whit the inverse parameter optimisations, carried out using DISC model, an excellent agreement between measured and fitted infiltration curves was obtained. Moreover, the estimated unsaturated hydraulic conductivities compared closely with those obtained with Wooding's solution. The numerical inversion technique of tension infiltrometer data proved to be a promising tool for estimating the soil hydraulic properties.

Key words: Clay soil, Infiltrometer, Parameter estimation, Soil hydraulic properties.

A study of watershed management in the eastern hill of Nepal

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Abstract

The Watershed Management in the eastern hill of Nepal ad High Mountain thrust area of the FARM program has established excellent models of empowering the farmers for sustainable watershed management through their own organization. These organizations are federations of farmers groups networked in a small watershed consisting of 200-500 families. It is achieved at the demonstration sites in Udaypur and Khotang districts of Nepal that farmers watershed management networks can be very effective in empowering them to take their own decisions for natural resource management. This achieved by capacity building direct quick tangible benefit generation to farmers themselves. The farm program is expected to help replicate it nation wide as a model.

The Eastern hill of Nepal sharp physiographic and climatic contrast despite its small area. Every body of the world know that about two third of the Nepal is composed of hills and mountains with steep to very steep slopes. It has several watersheds ranging from gig basins to micro-watersheds of the smallest size, where more than 90% of the total population live and practice subsistence farming. Many of these watersheds are in a state of physical and biological deterioration fast due to population pressure. When there is a very old tradition of watershed management in eastern hill of Nepal, watershed degradation and its consequences were realized by HMG/N only about two decades ago. At present watershed management activities are extended to 40 of 75 districts of Nepal, considering soil conservation as one of the primary programs of the forestry sector, various activities like soil fertility and productivity enhancement protection of physical infrastructure, community forestry, soil conservation and extensions programs are being implemented in these districts. User's groups for community participation in soil conservation are a perquisite policy of our country. The user's group concept as been very successfully used for protection and regeneration of community forests around villages where by the community, lands are leased to the village people for 15-45 years and people have been harvesting their benefits. All activities of soil conservation and watersheds management are aimed at sustainability, developing and designing social and community initiatives and self-reliance mechanisms.

Session: *Soil erosion*

Influence of different soil use on erosion and nutrient losses in a hilly clayey Mediterranean area (Tuscany, Italy).

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Abstract

A three-year field study aimed to determine the effect of different soil use on erosion and nutrients losses was carried out on a hilly (25% slope) clay soil in central Italy (Tuscany). Eight plots 15 m wide and 75 m long (four different soil uses replicated twice) were managed by continuous fallow, winter wheat, alfalfa and grazing shrubs (*Atriplex halimus L.*), and monitored with an electronic hydrological unit for surface runoff and soil erosion measurements. For each runoff event the following parameters were determined: nitrates, ammonium and soluble phosphorus in runoff water; total nitrogen, available phosphorus, bioavailable phosphorus and total phosphorus in suspended sediments.

Statistical analysis of data indicates significant differences in runoff volumes, soil erosion and nutrient losses among the plots under different soil use. Grazing shrubs showed a drastic reduction of runoff and soil loss with respect to winter wheat and alfalfa treatments. Continuous fallow, as expected, evidenced the highest runoff and soil loss, while wheat and alfalfa did not show significant differences over the three year period.

Continuous fallow and winter wheat evidenced the highest losses of nitrate in each year, and showed very high nitrate concentration in runoff water during the autumn. This is due to intense mineralization of organic matter in the summer, which produced in these plots high nitrate concentration in the soil. Alfalfa plots showed elevated nitrate losses only during the spring of the first year, after the sowing and fertilization, when vegetation cover was insufficient to protect the land from erosion. After this period nitrate losses in these plots were very small. Only the winter wheat plots showed losses of soluble phosphorus that were quite low, and were restricted to runoff following the autumn fertilization.

Nitrogen and phosphorus losses with sediment were strictly correlated to soil erosion, but the sediment composition showed interesting variation over the three year period. Sediment coming from grazing shrubs and alfalfa showed an enrichment on nutrient content during the study period, while sediment coming from continuous fallow evidenced a reduction on phosphorus concentration.

Ke ywords: soil erosion, surface runoff, nutrient losses, nitrogen, phosphorus, soil use

Impact of cropping systems on soil erosion in the clay hills of central Italy

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Abstract

Soil erosion is a priority environmental issue in the hills of Central Italy as it is cause of depletion of agricultural soil fertility and of sediment yield in rivers and lakes.
The aim of this study was to assess the impact of three different cropping systems on soil erosion by surface runoff in the clay hills of the Marche region (central Italy). In this area, cropping systems are heavily based on annual rotations of sunflower and durum wheat, as a consequence of the application of the European agricultural policy, which currently includes subsidies to reduce agricultural inputs (fertilisers, herbicides etc.) to prevent negative impacts on soils and water. Soil erosion was continuously monitored for three years (1994-97) on three cropping systems:
A) sunflower-durum wheat rotation with conventional inputs;
B) sunflower-durum wheat rotation with restricted inputs on fertilisers and herbicides;
C) set-aside managed with mechanical or chemical control of weeds.
Treatments were arranged according to a randomised complete block design with three replications.
The monitoring device of each experimental unit was represented by a 50 x 7 m plot, arranged with the longer side parallel to the maximum gradient, isolated from surface water with corrugated fiberglass reinforced plastic, with a canalisation at the bottom to collect the water
The results show that the amount of soil losses occur mostly on a few summer rains characterised by high intensity (I_{20}max up to 60 mm h^{-1}) under the sunflower cover and a relatively high soil humidity (without cracking). In summer 1995, that was exceptionally wet (over 650 mm from June to September), soil losses were as high as 60-70 t ha^{-1} on the sunflower cover (cropping system A and B) and 10 t ha^{-1} on the set-aside dead vegetation treated with herbicides.
The soil losses measured on wheat cover in 1994 and 1996 were relatively low if the soil was fully covered.
The fertiliser and herbicide restrictions had no significant effects on soil erosion while straw residuals significantly reduced soil losses in autumn 1996 in comparison to the ploughed bare soil.
The paper discusses all relevant events of runoff and soil erosion recorded in the three years experiment.

Key words: sunflower, durum wheat, low-input agriculture, set-aside, central Italy, surface runoff

Soil erosion in a small watershed related to the land use

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Abstract

The study of environmental impact of soil erosion due to water runoff is very important to protect soil quality and fertility. In order to estimate the phenomenon at watershed scale, discharge and sediment content in a stream are studied.

A small watershed (2.75 km^2) in a hilly area South East from Bologna, Italy (44°25' N, 11°28'E, altitude between 84 and 350 m a.s.l.), drained by the Centonara stream and characterised by seasonal flow, has been monitored since 1994. Meteorological and hydrological data are recorded continuously, water of the stream is sampled in order to estimate sediment amount. Several thematic maps of the area has been produced (slope, pedological, geolithological, morphological). In each agricultural season the land use (tillage, crop, chemical treatment, fertilisation, etc.) is mapped (1:5000) interviewing the farmers about crops and soil management.

The findings of the survey showed that the average slope of the whole watershed is 28.2%, the slope of the agricultural area, which represents 45% of the total, is 15.2%, five percent of the watershed is badlands and about 43% is natural vegetation, both woods and bushes, balancing the agricultural area. The climate is typical of the low hilly area of this region, with two rainfall picks in spring and fall.

In the present study seasonal soil loss from the watershed, due to the soil into the water (particle size distribution lower than 2 mm), is measured and related to the precipitation characteristics (quantity, intensity, frequency, distribution) and to the various agricultural soil use and management, in order to separate the impacts due to agricultural practices from those of natural erosion. The results show a different trend of the amount of sediment from year to year and a significant correlation with the agronomic management.

Key words: Erosion, Watershed, Land use and management

Databank on the field plots for soil erosion studies in Bulgaria: construction, analysis of the data and some uses

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Abstract

Soil erosion is one of the most serious soil degradation processes on the territory of Bulgaria. Since 1958, field plots have been set up in Bulgaria to study soil erosion at diverse soil, climate, topography, cover and management conditions. Such studies have been carried out in nine experimental fields around the country. This paper presents the results from the first attempt made in Bulgaria to construct a databank on the field plots for soil erosion studies. Some uses of the data hold in the databank, such as evaluation of the soil erosion factors and validation of the Universal Soil Loss Equation, and a daily rainfall erosivity model are discussed as well.

The design of the databank on the field plots for soil erosion studies suited the following requirements: (i) to systematise and suitably organise all available data characterising the studied sites, soils, tillage, erosion prevention measures, plant biometrics, rainfalls, soil loss and runoff; (ii) to calculate automatically the main rainfall characteristics, rainfall erosivity and soil erodibility indices; (iii) to be user-friendly. Thus, the databank was originally designed for PC in MS Windows'95 environment under Excel'97. It was based in a folder DaBasEr (Data Base on Erosion), which included five files named after the information they contained (RAIN, SOIL, LOSS, RUNOFF and BIOMETRY), each one including nine worksheets referred to the place of the experimental field (Dzhebel, Karnobat, Kardzhali, Mirkovo, Ruse, Suhodol, Topolovgrad, Troyan and Valkosel).

Currently, the databank holds characteristics of 2043 rainfall events, of which 688 are erosive, runoff amounts for 2690 plot/events and soil loss values for 1965 plot/events, measured on field plots sloped from 3.5 to 10° with length from 8 to 70 m in the nine experimental fields. The data hold at this time in the databank on the field plots for soil erosion studies are used to evaluate the soil erosion factors and to validate the Universal Soil Loss Equation, and a daily rainfall erosivity model for the natural conditions in Bulgaria.

Once a large part of the available data from field plots for soil erosion studies was organized in a databank, some gaps appeared in the experimental outputs and both the soil, and the climate conditions represented. Nevertheless, as a databank is never complete, this version holds what is currently collected. When new information becomes available DaBasEr can be easily updated by additional data and formulas to calculate further characteristics of rainfalls, soils and plants.

Key words: databank, field plots, soil, erosion, rainfall erosivity, USLE validation, Bulgaria

New methodologies for field measurements of tillage erosion

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Abstract

During the past 10 years, tillage has been recognized as a cause of landscape modification and one of the major sources of soil erosion and translocation along hillslopes. This paper aims at presenting a set of new methods for assessing soil translocation by tillage, based on carefully planned experiments and on field evidences. A low-induction electromagnetic probe (EM38), usually adopted for non-invasive EC measurements in saline soils, has been used for tracing and measurement in soil translocation field experiment. The method is non-invasive and based on mapping of the electromagnetic anomalies induced by metal tracers incorporated into the soil. The proposed technique allows replacement of tracer excavation and survey method usually adopted in these types of experiments. The procedure reduces dramatically the time for each single experiment and allows the measure of the effect of multiple tillage operations.
Evidence of tillage erosion is frequent along field borders or in the presence of trees and electricity and telephone poles along hillslopes. Isolated poles in the field obstacle the normal soil flux along the slope. The geometrical survey of the protruding oblong structure formed around them, allows the calculation of eroded/translocated soil amounts for the period of time during which the poles have been standing, which in our case varies from 10 to 35 years.
These results are in clear agreement with the findings of field experiments on soil translocation by tillage carried out by several authors on the effect of local curvature.
Simulation and scenario analysis of soil translocation with SETi (Soil Erosion by Tillage) model in hilly areas of Tuscany has been compared with experimental results and field evidences.
Finally, some consequences of mid-term tillage erosion in hilly environment have been analyzed.

Key words: Tillage erosion, modelling, field survey

A soil physical based model to predict runoff and soil erosion

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Abstract

Erosion plot measurements used in the development of the RUSLE are measurements on hydrological areas isolated from surrounding influences, with consequences when applying RUSLE at a watershed scale.
In order to compare the generated erosion patterns, a physical based model such as the EROSION-2D/3D model (Schmidt,1991,1992,1996) was used requiring data needed also for the RUSLE, with changes introduced in the hydrological submodel and in the soil transport function. The modified EROSION-2D/3D model was identified as STM-2D/3D, an event based Sediment Transport Model, which was implemented in a 2D hillslope and 3D watershed version.
Some major changes introduced were : (1) the infiltration model for unsteady rain events, (2) the development of an implicit flow routing finite difference scheme of the kinematic wave and (3) a soil transport function based on stream power (Nearing et al, 1997) as predictor for the unit sediment load.
For a small 142 ha catchment within the Kemmelbeek watershed in West Flanders Belgium, a comparison was made between the potential erosion losses per agricultural field calculated with the RUSLE and the STM-2D/3D model. The RUSLE potential erosion losses were calculated with the respective erosivity values of the events. The overland flow estimated with the STM-2D/3D model was calibrated using discharge measurements.
The runoff amount for high erosivity events (usually summer events) was overestimated by the RUSLE and underestimated for low erosivity events (in general winter events). The spatial erosion pattern generated by both models was substantially different.

Experiments and algorithms for linear erosion and their evolution

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Abstract

One of the main component of water erosion in agricultural field is due to linear incision, namely rills and ephemeral gullies. Recently attempt have been made to model rills and gullies: besides EGEM (Woodward, 1999) and Sidorchuck's (1998) models a new version of LISEM has been recently enriched with a routine on ephemeral gullies (van de Vlag et al., 2000) which is based on the empirical threshold relationships found by Poesen et al. (2001). Casalì et al. (2000) have presented another approach to gully erosion, while other authors point out the importance of seepage and knickpoint dynamics to explain gullying. Experiments have been recently reported regarding gully generation (Bennet et al., 2000).
Here a set of experiments, exploring the condition for initiation and development of linear incisions and conducted both in the field and in the laboratory, will be discussed. The data allow the confirmation of the general trends presented by Torri and Borselli (2000), which generalize and expand the approach by Foster and Lane (1983). This allows the construction of a simple model based on the above mentioned equation, the projection of which are positively compared with the threshold equations found by Nachtergaele et al. (2001). Linear incision starts when the concentrated flow is able to express waves as large as 4-6 cm over a 10-15 cm long trait. The flow initially wet a wide perimeter that is later reduced once incision begins. Relationships between channel erosion and flow characteristics such shear stress or stream power is discontinuous and appears to be dominated by depth/width critical ratios, typical for given discharge and slope.
The results of the experiments, even if well in agreement with established theories, reveal that the established equations must be applied with care and that linear incision is very sensitive to processes and to a spatial and temporal variability of soil parameters that modellers usually ignore.

Predicting soil water erosion using the ImpelERO model and a mapped reference area in the Sevilla province (Spain).

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Abstract

Soil erosion by water is one of the biggest problems in agricultural landuse and management because it affects soil loss as well as on- and off-site damages.
The ImpelERO model was used to develop an approach physically valid for a larger spatial unit and to predict the water erosion depending on soil type and its management. This work was carried out as a part of the SIDASS EU project. Data on climate (taken from the on-site meteorological station), data on soil properties and on soil management were needed for the modelling. Also, a soil map (scale 1:2.000) of the reference area, a 40ha experimental farm in the Sevilla province (Spain), was used. In this area, three typical types of soils for the Mediterranean region (Aquic Haploxeralf, Mollic Haploxeralf and Tipic Xerochrept) were chosen to measure physical and chemical properties as well as runoff and soil loss. Two different management treatments (traditional and conservation tillage) were selected as representative for olive orchards in the reference area. The traditional tillage method consists mainly in using mouldboard ploughing and cultivation implements; whereas, the conservation tillage is characterised by not using mouldboard ploughing, by reducing the number of tillage operations and by using the crop residues as mulch. The crop used in the conservation plot is Triticale (crossing between *Triticum* and *Secale*).
A validation of the model was developed successfully with the samples of runoff and soil loss collected in microplots. The lowest soil loss and runoff values were found in plots with conservation management.
The ImpelERO model is a prediction tool for water erosion and for selecting appropriate management practices. The spatialization of the results was done with the help of soil attribute databases and GIS-based maps.

Key words: Water erosion, SDBmPlus database, GIS, expert system/ neural network model, Agricultural management practices

Runoff and erosion in volcanic soils: deterministic and semi-empirical modelling

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Abstract

To assess the hydrologic behaviour of the volcanic soils of Azores as influenced by land use, two experimental plots have been installed for observation of soil hydraulic properties, soil water regime, runoff and sediment transport. One plot has been for three years under permanent psture for grazing, and the second was with pasture for the first year, then with corn for sillage during the second year, and replanted again by pasture after corn harvesting.
The simulation of the hydrologic processes was performed with the model OPUS using both the deterministic and the semi-empirical versions of the model to compute runoff and erosion. The soil water movement in the soil profile is simulated with the Richards equation requiring that soil hydraulic properties be described by modified Brooks and Corey relationships. Adopting the deterministic version, breakdown rainfall data is required, infiltration is computed using the Smith and Parlange equation, runoff is simulated by the kinematic wave approach, and erosion and sediment transport are described by a mechanistic detachement and transport submodel. When the semi-empirical version is selected, daily rainfall data is used, infiltration and runoff are computed with the SCS curve number method, and erosion is computed with the MUSLE method.
This paper shows the calibration and validation of OPUS for both approaches. Results include the calibration of the soil water component, comparing simulation with observation data. Results for runoff and erosion obtained with both versions, comparing simulated with observed data are analysed at both the event and the seasonal scales. Results show that pasture lands produce very small runoff (1% of rainfall) and negligeable erosion (3kg/ha/year) and that runoff increases to near 20% of rainfall, and seasonal soil losses increase to near 15 ton when the soil is non covered from planting to full establishment of a new pasture.

Spatially distributed application of USLE to a small agricultural catchment

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Abstract

The paper deals with the application of a spatially distributed form of *Universal Soil Loss Equation* (USLE) to an experimental catchment in the Marche Region in Central Italy (Spescia catchment). The USLE is the most widely applied approach for the evaluation of soil loss. However its application at the catchment scale has some severe limitations. The distributed form of the USLE (DUSLE) (Bischetti, G.B., Gandolfi, C. , Whelan, M.J., Distributed evaluation of soil loss in an alpine basin using an integration of the *USLE* and digital elevation models, Proceedings of the *EurAgEng* Conference, Oslo, Norvegia, 1998) overtakes some of these limitations by exploiting the new opportunities offered by Geographical Information Systems and the most recent techniques for flow direction identification from regular grid Digital Elevation Models (DEM). In particular, the DUSLE implements an innovative methodology that explicitly accounts for the influence of convergent surfaces in the calculation of the topographic factor.
The Spescia catchment (about 90 ha) is a typical small agricultural watershed characterised by gentle slopes and a dense artificial channel network. Since 1997 the catchment is studied in a research project leaded by DIBIAGA which carried out exhaustive and detailed surveys on soil characteristics, crops and in general on all the agronomic techniques. Moreover, the catchment outlet was instrumented with a level recorder and a pump sampler for suspended sediment loads. All the information collected were entered in a GIS framework and discretised by a regular grid with cell size of 20 meters, to obtain the entry values for all *USLE* factors for each cell of the catchment. The evaluation of the factors (erodibility, topography, crop and management practice) was based on accurate analysis and takes account for the spatial heterogeneity of topography, soil characteristics and management practices, except for the erosivity factor which was estimated on monthly data because a lack of more detailed rainfall data. In spite of that, the results obtained are promising and DUSLE may be considered a useful tool for agricultural terrain management purpose.

Key words: Soil erosion, modelling, USLE

Factor analysis to identify aggrading and degrading soil processes in cultivated and abandoned fields of NE Spain

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Abstract

In Spain marginal soils on steeping slopes have been exploited and subsequently abandoned or maintained at very low agricultural management. Previously managed areas with adequate fieldwork, terracing and suitable drainage conditions had been therefore converted into very vulnerable to degradation according to free colonisation of opportunistic vegetation, wildfire recurrence, and the conditions of the soil at the release. The extent of environmental deterioration may be ascribed to the increasing erosion potential produced by soil compaction and crusting, runoff, loss of organic matter and nutrients depletion. The objective of this research was to identify underlying patterns in soil properties through different environments and after different rainfall events using factor analysis, in order to determine how the factor patterns can describe aggrading or degrading soil processes along the period of observation. Accordingly, 5 different environments differing in land use and age of abandonment were selected in the Serra de Rodes cathment, Alt Empordá, Girona, Spain. Lithic Xerothents: 1) at low agricultural management, cultivated with olive trees (*Olea europea*) and vineyards (*Vitis vinifera*), 2) grass (*Brachipodium ratusum)*-dominated (5 years abandonment), 3) *Cistus monspeliensis*-dominated (25 years abandonment), 4) wooded with naturally regrown *Quercus suber* (50 years abandonment) and, 5) planted approximately 50 years ago with *Pinus sylvestris* were sampled seasonally at 0-10 cm depth and analysed for sand, silt and clay content, cation exchange capacity (CEC), extractable K, Ca, Mg and Na, organic C and N. After the 10 rainfall events recorded in summer and autumn 1999, soil were analysed for moisture content, bulk density, mechanic impedance and surface temperature. Likewise collected runoff water was analysed for dissolved K, Ca, Mg, and Na, dissolved organic carbon (DOC) and dissolved organic nitrogen (DON) whereas the eroded sediments were checked for organic carbon and total nitrogen content. All data related to canopy covers, bare soil portions, physico-chemical properties of soil environments, as well as the data from any individual rainfall events were run simultaneously by using the varimax rotation method. For any analysed rainfall event, a three-factor model accounted for 70-80% of the total variation in data. As expected, within-rainfall soil conditions governed runoff, sediment yield and nutrient depletion and soil response was different according to rainfall amount, thereby determining the factor patterns. When rainfall amounts did not exceed 25-35 l/m^2, the first factor always showed high positive loadings on runoff, sediment yield and related parameters (DOC, DON, dissolved K, Ca, Mg, K, and organic carbon and total nitrogen in the eroded sediments) and was termed the degrading factor, indicating that degradation processes may prevail within the environments. The second factor had high positive loadings on soil organic C, total N, CEC, exchangeable bases and a high negative loading on sand, and represented aggrading soil properties produced by litter accumulation and organic matter under grass, shrubs and woodland. The third factor had positive loading on bare soil and negative loadings on undergrowth, silt and clay and was termed the soil texture-plant protection factor. With rainfalls higher than 50 l/m^2 factors 1 and 2 showed opposite patterns and both had high positive and negative loadings either on aggrading or degrading soil parameters, indicating a random soil surface response.The factor analysis provided a tool for grouping correlated variables into uncorrelated factors and allowed to better understand the natural aggradation and degradation processes in a sequence of abandonment.

Delineation of Response Units (RU's) by remote sensing and GIS analyses and their application in regionalization of erosion process dynamics

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Abstract

Water resources management is an important issue in Southern African Countries. With respect to water quality problems, the understanding of the dynamics of integrated soil erosion processes in river basins is of crucial importance. This study regards the delineation of response units in the Mkomazi-river catchment (Kwazulu/Natal- South Africa) and Mbuluzi-river catchment (Kingdom of Swaziland). It was carried out within the framework of an interdisciplinary EU-funded Project aimed at developing an Integrated Water Resources Management System (IWRMS) for water resources analyses and prognostic scenario planning in semiarid catchments of Southern Africa. Within this more general framework, particular attention was focused on the identification of sediment source areas. For this purpose the concept of Erosion Response Units (ERUs) was developed and applied. The ERUs are used to identify areas affected by different types of erosion, as well as modelling entities for erosion simulations. Physically based hydrologic models and erosion models (SCHULZE 1995, SIDORCHUK 1996, 1998a,b, 1999) were therefore applied. The input data were obtained by remote sensing techniques (API method) and GIS-analyses. The two examples from Southern Africa show that the methods applied are able to identify areas affected by different types of erosion. Furthermore it is possible to estimate the amount of soil loss due rill-interrill erosion processes for characteristic subcatchments. This results then were regionalized for the entire basin to get informations about the catchmets susceptibility to erosion.

Testing the WEPP soil erosion model in a small catchment of Bolivian Andes

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Abstract

This study describes a possible way of the WEPP model application in a rural planning in Bolivia.
The USDA Water Erosion Prediction Project is a physical-based model which predicts soil loss and sediment yield from overland flow on hillslopes, so that a user is allowed to select conservation measures to control soil loss.
The parameters taken into consideration for the computer simulation concern climate, soil, topography and agricultural management. Data are arranged in four input files. The variables considered are temperature, precipitation, solar radiation, dominant wind (CLIMATE file), soil depth, clay %, sand %, organic matter %, CEC, rock fragments, porosity, water saturation, hydraulic conductivity (SOIL file), steepness, shape and slope length (SLOPE file). Finally, four typical crops of the area are considered as inputs in the MANAGEMENT file.
Measurements were taken in the field to validate the model on a research area in the Rio Espejos catchment (Middle Piraì Basin), in the Province of Santa Cruz de la Sierra. A partecipatory planning conservation program has been developed in this area since 1991 by FAO.
It emerged that soil loss is strictly related to slope steepness and land tenure; the most influent pedological parameter in predicting erosion seems to be the soil structure. In particular it was observed that soil erosion risk increases with loamy texture, and that rangeland is the less "aggressive" land use in the area investigated, whilst potato and yucca are the most sensitive crops.
As part of the land evaluation, the socio-economic conditions were considered in order to evaluate the chance for WEPP to be implemented as a partecipatory technique. In this regard, the results recorded indicate some possible scenarios for WEPP application to rural conservation planning in developing countries. This approach is supposed to be easily supported by local actors.

Key words: WEPP, sol erosion, land use, Bolivian Andes

Management practices for soil and water conservation in the highlands of Ethiopia

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Abstract

Soil conservation and sustainable land use concern almost everyone in the world. This is particularly true in developing countries such as Ethiopia where population pressure is very high, land degradation is severe, and even short-term survival is at stake. Most of the productive topsoil in the highlands has been degraded, resulting chronic food shortage and persistent poverty. Annual soil loss in Ethiopia is estimated at between 1.5 and 2.0 billion tones. Of this, 50% occur in cropped lands where soil loss may be as high as 296 t ha-1 year-1 on steep slope. The rate of soil erosion and land area taken out of production is increasing due to human and livestock population growth, erosive climate topography and poor management practices. It was estimated that erosion has already affected 25% of the highlands are seriously eroded to be economically productive again. The highlands (>1500 m asl) receives high rainfall during the rainy season June-August which causes water logging on Vertisols. Conservation practices to control water runoff and soil erosion on Ethiopian soils have ranged from structural measures such as contouring and terracing, to vegetative practices including crop rotations. The objective of the research in soil conservation is to generate technology that can control erosion and improve the fertility status of the soil. The research follows a runoff plot approach on one hand and a catchment approach on the other hand. Results of different trials at different locations showed that soil loss and slope length have an exponential relationship and were significantly correlated. On the other hand runoff declined as slope length increased owing to increased infiltration on longer slopes. No matter how effective the soil conservation measures are in minimizing soil loss and thereby maximizing crop yield, the evaluation of such conservation measures depends on the extent to which farmers adopt them. Thus, to have effective and adaptable conservation measures the approaches should be holistic to include as many parameters as possible in a watershed bases. Indigenous as well as agroforestry systems newly adapted to the locality are important conservation measures which can contribute both to reducing erosion and increasing soil fertility. In contract, physical conservation measures play a key role in areas where vegetation cover is highly degraded or where there is limited growing potential vegetation.

Key words: Run-off, soil loss, conservation measures

Evaluating soil erosion with RUSLE and WEPP in an alpine environment (Val Dorena – Central Alps, Italy)

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Abstract

A complex slope instability phenomenon affects the upper part of the Dorena Valley (NE of Edolo, Central Alps, Italy) since the beginning of 1900.
An integrated multi-disciplinary approach was adopted to get a clear comprehension of the phenomenon. Field surveys and multitemporal aerophoto interpretation were carried out in order to interpret the structural, geological and geomorphological settings in which the instability developed, and to explain time evolution of the phenomenon.
The upper part of Dorena Valley is affected by several mass movements: rotational slides, rockfalls from metamorphic weak rocks (cataclasites), cropping out in the study area and debris torrents. The whole area also shows accelerated erosion phenomena such as interrill, rill and gully erosion, leading to a progressive retreat of the erosion scarp.
In particular, the soil loss research was carried out in the lower part of the slopes stability, measuring soil loss from seven experimental plots and applying two mathematical models, RUSLE and WEPP, which were developed for agricultural environments. The soil loss produced from each experimental plots (bare and grass stripped) was collected by simple metal gutters, 0.5 m long and 0.1 m large, closed at the sides and fitted with a movable lid. Sediment samples collected in such a manner were analysed in the laboratory to obtain both quantity and grain size distribution data.
RUSLE (empirical model) and WEPP (physically-based model) were applied estimating the parameters by means of field surveys, laboratory analysis and literature data, without any calibration procedure. Rainfall data were obtained from an automatic rain gauge next to plots, whereas slope steepness values were obtained from a 1:500 scale topographic map.
Although the Alpine environment is not typical for the two selected models, results obtained from WEPP runs suggest that such a model may be looked as a promising tool also for the Alpine environment. On the contrary, RUSLE appears to be completely inadequate.

Key words: Soil erosion, numerical modelling, slope stability, central alps, weak rocks.

Evaluation of the vegetal cover in conservation agriculture in GuadalquivirValley

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Abstract

Soils in the Southern of Spain are generally subjected to intense hydraulic erosion processes that are enhanced by their topography and by a traditional tillage management, keeping the soil unprotected a great part of the winter-autumn season.
Conservation agriculture systems, based on keeping residues of previous crop, and direct planting, are the best way to combat the erosion, and they also led to a decrease in the costs.
Evaluation of vegetal cover and its evolution in the time is necessary in studies and research on these soil management systems. Ordinary measurement methods based on gravimetric techniques and the needle of Bufon are too slow and complicated, development and use of automated methods that complement or replace them, are necessary.
Artificial vision techniques appear to be the best way to get it. In this work, studies carried out in this line are showed. Algorithms to distinguish vegetal cover from nude soil and to calculate the percentage of covered soil were tested, taking as a reference the gravimetric method. Experiments were made on vertisol soils of the Guadalquivir Valley, and the results are very encouraging.

Measure of root tensile strength and its interaction with soil in slopes stability problems

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Abstract

The role of vegetation in slope stability problems is well known long ago. In particular, the root distribution in the soil is one of the most important factors in the erosion control. In fact, their action is useful whether in hydrological processes (improving stability by decreasing soil moisture, pore pressure and lowering sheet erosion), and increasing mechanical properties.
The mechanical reinforcement of a rooted soil may be ascribed to soil-root interaction, which transfers tensions developed into the soil to the roots mobilising their tensile strength.
This contribute may be important especially for shallow soils, which are relevant in the Alpine and Prealpine environment. Quantification of the roots effects in soil conservation is also very important in the bioengineering techniques, especially in structure design.
The shear resistance increment due to root presence can be studied from a quantitative point of view, by using reinforced soils models. Unfortunately the parameters needed in such models are known only for few natural and synthetic materials and very few values are available for roots.
At this point it is important to determine an experimental methodology to measure tensile strength and use it to define mechanical properties for different kinds of vegetation species.
Without a standard general procedure we have defined a new one using, like first input, precedent experiences of other Authors, summarising their works and introducing technicians aspects never considered before (drawing, clamping, speed testing, etc.). In order to evaluate root tensile strength we have projected and build an apposite instrumentation (Fig. 1).
The work made permitted us to quantify roots mechanical parameters and roots distributions parameters for two species (willow tree and green alder), useful in slope stability problems: tensile strength, diameters frequencies, roots area and finally roots area vs depth.
At the meantime we have defined a mathematical model that using indefinite slope methods, determines increasing shear resistance due to roots presence. In other way we can define safety factor of slopes, quantifying the positive contribute of vegetation.

Key words: soil stability, root strength, laboratory measurement

Empirical and parametric approaches to study loss in soil productivity through soil erosion

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Abstract

Empirical and parametric approaches have been employed to study loss in soil productivity by soil erosion in a representative catchment of submontane Punjab. The area suffered from moderate erosion risk. The approaches take into account soil attributes related to crop growth which in turn are affected by soil erosion. The empirical equation explained 90 percent of the variation in maize (*Zea mays*) yield due to different factors. The pH was found to be the most significant factor in affecting the yield of maize crop followed by solum thickness. The productivity index varies from 0.18 to 0.89 in different pedons in the area as computed by parametric approach. The factors considered in parametric approach partially explain the variations in crop productivity. The employed parametric approach needs suitable modification for the area. Of the two approaches used, empirical approach explains the results satisfactory for the area.

Key words: Soil erosion, productivity index, sufficiency functions, slope transect

The effects of different tillage systems on soil erosion

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Abstract

Soil erosion has became a serious problem in Tunisia since the introduction of mechanization in the cultural practices. Indeed the thorough soil loosening by ploughing and the multiple ways of soil cultivation that is performed in the direction of the slope have considerably amplified this phenomenon.

The effects of the soil tillage (reduced tillage and no tillage) and the orientation of the crop (contour planting, uphill and downhill planting) on the permeability, the runoff, the soil water content and the soil losses were studied in a durum wheat crop planted in a field with 10% of slope.

The results showed that reduced tillage allows a better permeability of the rainfall and that crop orientation in contour lines reduced runoff. The combination of the reduced tillage in contour line resulted in a better permeability and a less water and soil losses by runoff. The examination of the profiles of the water contents confirms the above results by the superiority of the reduced tillage in contour line which is being characterized by a more significant moistening and a lower soil drying due to a less weed competition. Wheat yields of this field treatment were higher than the other ones.

Soil erosion control on vineyard in Tokaj region

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Abstract

In the north-eastern part of Hungary, wines can be produced under optimal climatic conditions on hilly areas. The best quality wines are produced on southerly slopes 150-200 m about the sea level, where the sugar content of the berries is much higher than on the lower slopes. Although the rainfall is sometimes the limiting factor in summer, especially on south slope with higher overland flow and less soil water storage capacity, but heavy thunder-storms often damage the bare soil surface, degrade the soils and lead to on- and off-site damage under vines. Since the grape plantations are found on loess, which is the most erodible sediment in the world, and its rate is strongly affected by the manner of cultivation soil protection measures against erosion are needed.

The aim of this study was to determine the factors of erosion responsible for runoff and soil loss. Several soil conservation practices were studied, including soil management practices and the effects on the physical and chemical properties of the soil as well as the influence on yield and wine quality were evaluated.

In the past the general planting method was building terraces. Nowadays the vineyards are mainly cultivated "up and down" along the slopes, due to the better ecological and economical conditions, where two difference kind of agricultural practices are used for the inter-row areas. These practices can be identified as a „conventional" periodic tillage, which leaves the soil bare throughout most of the year, and so called „conservation", which provide protection to the soil surface. Sometimes conventional tillage is effective because increases water storage capacity in the plough layer and reduces velocity of runoff and rate of surface sealing. But in some cases it provides not enough protection against soil erosion in the steep slopes.As conservation tillage two methods are common in the study site. Leaving a permanent natural grass cover or other low growing plants as a crop cover. Generally, a continuous green cover is very effective in reducing runoff and soil loss. But such an operation in shallow soils, seems rather unfeasible from a soil water uptake of vine point of view, considering the available amount of water during the hot, dry summer is too small for growing vine. Therefore, as temporary protection cover for the hazardous season barley is planted. On the other hand appreciable crop residue, like straw mulch protects the soil from detachment by water but on the steep slopes do not support for traffic of tractors.

Because the erosion hazard due to rainfall differs by season, and crop and cover conditions also change with the season, it is desirable to evaluate the effects of conservation tillage on soil erosion risk for different seasons. Good planning is important for any soil erosion system and must also consider the demand of the vine. Sometimes successful conservation tillage influences grape growing adversely beside reduces soil and water losses. Therefore it is necessary to choose a proper agronomic methods, including applied plant and management, may shorten the period in which erosive rainfall can cause significant damage to the soil. On some fields under the conditions of limited available soil water adequate erosion control may require structural measures, including terraces.

Key words: erosion control, vineyard, green cover, straw mulch, and bare fallow

The use of organic matter "Bokashi" to reduce soil sticking at moldboard plow surface

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Abstract

Some studies have shown the result of utilization of organic matter in improving soil condition. Previous studies showed that organic matter could reduce tillage draft. Legume crops, peat, green manure, straw or some factory waste products are common organic matters used to improve soil fertility. However, since the organic materials have different chemical and physical characteristics that some are more effective than others, it is important to study how effective each of them will be in improving soil condition. Beside its function to improve soil condition, the organic matter with its characteristics has potential to reduce soil sticking at soil tillage tool. Soil sticking at tillage tool decreases efficiency and quality of tillage. The tool with sticked soil on the surface will effect the function of blade to overturn the soil perfectly, beside the tool will have additional load to carry during operation and this will increase energy for tillage more than in normal condition.

The objective of this study is to find the effect of organic matter (corn straw bokashi) on soil sticking at moldboard blade and how far the material can improve soil condition.

The study involved laboratory experiment and field experiment, using organic material corn straw compost called "bokashi". The bokashi with two levels : 12 ton/ha (P1) and 16 ton/ha (P2). Soil sticking was evaluated during tillage operation at the filed with three levels of moisture content : below field capacity (A1 : 35.09 – 39.29 %), at the field capacity (A2 : 43.16 – 44.04 %), and above field capacity (A3 : 45.39 – 51.96 %). Moisture content was considered based on soil consistency test. Uniformity of soil along the path was created by tillage during mixing of bokashi. The sticked soil was determined by mapping the tool surface after sticking and also by weighing the sticked soil at the blade. Profile mapping was done using corelCHART computer program.

The result showed that bokashi gives significant effect to the quality of tillage showed by penetration resistance and bulk density. Penetration resistance of plots (A1P1, A2P1, A3P1, A1P2, A2P2, and A3P2) with bokashi are lower than plots without bokashi. Based on the observation data, the same pattern was found to bulk density of plot. With bokashi the bulk density is lower than that of without bokashi. In general, beside a significant change of penetration resistance and bulk density, there is also a change in soil sticking. The most change was on the plot with moisture content below field capacity and the lowest was on the plot with moisture content above field capacity. The greatest soil sticking was on the plot with moisture content above field capacity (12500 gr). The lowest soil sticking was on the plot with bokashi 16 ton/ha, that was 1228 gr.

Key words : bokashi, soil sticking, tillage tool

Seasonal changes in surface runoff from a silty-clay soil of the Lower Po Valley.

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Abstract

The amount of water which can be lost by runoff depends on soil hydrological properties, surface roughness and slope. Since the plain is only rarely characterised by sloping conditions, the study of the runoff process related to it has, until recently, been quite infrequent. In this study the possibility of obtaining loss of water by surface runoff from a macroporous silty-clay soil of the Lower Po Valley was investigated. This soil is representative of those common to our region. The study area is characterised by groundwater recharging during the winter months.

Twenty rainfall simulations were carried out from August 1995 to September 1996, by means of an axial-flow rainfall simulator with full-cone nozzles. These simulations were grouped into 6 cycles. The first simulation of each cycle started with soil at its actual water content whereas, in the following simulations, the soil was kept wet between rainfall events. Each rainfall cycle included various numbers of simulations with differing rainfall volumes. Rainfall intensity was, on average, equal to 41 mm h^{-1}. The experimental plot, measuring 16.5 m^2, was located in a field which had been cropped with barley, and which had been left untilled after the harvesting of the crop. It was located at the edge of the field, on a gentle slope (5.5%), in order to facilitate any water runoff.

No relationship was found between rainfall height and runoff amounts; in fact, high rainfall amounts gave rise to scarce or nil runoff water loss in the summer months, whereas limited rainfall inflows produced quite abundant runoff events both in winter and in spring simulations. Based on soil water content and groundwater level, two situations were identified, which seemed to have different influences on water runoff: a) soil water content lower than that at field capacity, together with deep groundwater levels, as happened both in summer and in autumn rainfall simulations; b) soil water content higher than that at field capacity and high groundwater levels, as in the simulations which were carried out in late winter and in spring. Surface runoff occurred only in the latter case.

This experience allowed us to conclude that the retention capacity of this soil varied enormously, throughout the year: it tended towards infinity in the summer months while it was remarkably low in the periods characterised by high groundwater levels.

The role of forage shrubs in soil erosion prevention

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Abstract

Pasture improvement could represent a strategy for re-establishing pastoral activity and human presence in marginal internal lands of southern Italy, where hilly areas are prone to soil erosion and environment degradation. Pasture shrubs offer an alternative source of green fodder and, at the same time, prevent soil erosion.
This paper concerns two possible functions of Medicago *arborea*: fodder production and soil protection against the erosive capacity of rainfall. The research was carried out in the "Murgia", a hilly area in Apulia region. The shrubs were transplanted in 1991 on a 5000 m^2 surface (longitudinal slope = 5%) at two plant densities: 2 x 2 m and 2 x 1.5 m. By a rainfall simulator soil erosion was studied in 50 m^2 plots under the following conditions: bare soil, 2500 and 3333 shrubs ha^{-1}, before and after grazing. During each rain simulation where measured: water flow, rainfall intensity, runoff, nutrients and soil losses.
In spite of a low forage production (3 t ha^{-1} of green fodder *per* year) and short duration of grazed shrubs, the presence of *Medicago arborea* in the forage system of southern Italy is justified because a suitable shrub management let the availability of the green material in those periods of the year when the annual species do not grow actively. Moreover *Medicago arborea* controls soil erosion: runoff coefficients from a bare soil range between 3.2 and 30.7 % (as a function of the water initially stored in the soil profile), while in presence of a Medicago stand runoff coefficients are not higher than 9.7%. This highest figure was obtained in the stand with 2500 shrubs ha^{-1} after the animal grazing. Nitrite and nitrate content in flowed waters (0.11 and 0.04 g l^{-1} respectively) does not seem to constitute a real risk of pollution, also from a bare soil, where, after a 30 mm rain, the highest nitrate and nitrite values (2.41 e 4.74 kg ha^{-1}) were measured.

Key words: soil erosion, *Medicago arborea*, rainfall simulator, pasture.

Investigations for the stabilisation and lowering the soil erosion in slopes by surface modelling with the "Schmidt – Rekultivator"

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Abstract

Originally the Schmidt – Rekultivator was designed to favour start water logging in exhausted peat deposits. In the substrate exaltations and slots will be generated by the machine in consequence of vertically and horizontally oscillating steel blades. The increase of infiltrated water into the soil structure will cause a decreasing rate of erosive runoff water on soil surface. Furtheron the interlocking effect of multi layered relief structured soils is going to be examined with regard to their influence on the stabilisation of embankments and to reduce erosion in traffic lanes in sloppy areas.
Proceeding until now: By means of a variable experimental set up for slopes in combination with a rainfall simulator the mass discharges which are released by the runoff water over the soil surface can be investigated at different soil types by different inclination and surface structures. The slots of the generated relief shows thereby a positive mass uptake potential.
By measuring the infiltration behaviour of the used soils we can draw conclusions about the water retention as well as the behaviour of water conduction and consequently about the overland erosion behaviour. The overland flow can be effectively delayed by reliefing.
At the soil surface as well as for the interlocked structure between the different layers the shear strength was measured and shows the influence of the surface modelling or interlocking at a slope system. Normally with increasing inclinations the shear parameters decline. The aims of these investigations are to prove how to protect landslides and to reduce erosion by increasing the surface roughness. Different wetting intensities in the soil volume furthermore enhance the shear strength partially and also result in a better interlocking of the system.
First results will be demonstrated as a poster.

Small Watershed Contour-Based DEM Generation

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Abstract

Recently, the interest in contour-based digital elevation models (CB-DEM) has grown because of the awareness of needs to represent land surface with elements where runoff be better represented with respect to the connectivity and length of elementary cells.
This study has been oriented both to investigate the way CB-DEM generation works on a small scale watershed, and how the cell-base can be managed together with other geographic characters as soil type and vegetation cover, the latter being obtained by a dynamical database considering both natural and cropped surfaces.
The CB-DEM generation has shown to create a number of cells highly dependent on slope so that a further crossing with the other available layers can give rise to an unbearable set of new cells. In order to avoid the increase of the number of cells the prevalence method has been used instead of the splitting one.
Finally, the CB-DEM generator, whose design also accounts for hydrological network, has proven to sustain a land modelling framework which makes possible the integration of runoff and hydrological modelling.

Key words: runoff, watershed, DEM

A model approach for estimating the influence of compacted subsurface layer on soil erosion

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Abstract

It has been recognized that water erosion of soil and soil compaction are among the major soil degradation processes in Europe. Little is known about the relationships between compacted subsurface layers and the soil erosion processes. This study aims at developing a mathematical model for estimating the influence of soil compaction below shallow tillage layer on soil erosion.

The mathematical model is developed on the bases of data from field experiments with simulated rainfalls of intensities from 18 to 120 mm h^{-1} to study how continuous shallow tillage to 10-15 cm depth versus moldboard plough to 30 cm depth influence the soil erosion processes on Haplic Kastanozem. Both soils show compaction below the respective tillage layers. Soil with compacted subsurface layer is represented conceptually as a media consisting of two layers – tilled layer (TL) and compacted layer (CL), which differ in their physical properties. Indices of compaction and soil moisture distribution are defined to characterize the antecedent soil physical conditions. The index of compaction characterizes the degree of compaction by the relative change of soil bulk density in CL with regard to TL while the index of soil moisture distribution identifies the respective change of soil moisture content. Considered characteristics of the soil erosion processes are the minimal rainfall impacting energy needed to initiate runoff (E_0), the sediment load per unit rainfall impacting energy (SL) and the net sediment load per 50 mm rainfall (SL_{net}).

The model, which links E_0, SL and SL_{net} with the index of compaction, the index of soil moisture distribution profile, and the rainfall intensity, shows good capability of predicting the soil erosion characteristics depending on the degree of compaction and the rainfall intensity. The estimates of E_0, SL and SL_{net}, predicted by the model for five levels of the index of soil moisture distribution and four levels of the rainfall intensity, demonstrate the basic trends of soil erosion behavior under conditions of compacted subsurface layer. It is established that the type of the relationships between the soil erosion characteristics and the degree of compaction depends considerably on the index of soil moisture distribution. Generally, compacted subsurface layer affects soil erosion much more significantly when the moisture content is higher in topsoil than in subsoil. Verification of the model is needed for still broader ranges of the input soil characteristics to confirm its suitability for predictive purposes.

Key words: soil, erosion, compaction, shallow tillage, modelling.

Influence of rock fragment cover, vegetation and crusting on soil roughness, infiltration, and water content under semi-arid environment.

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Abstract

In arid and semi-arid regions, soil surface type and condition control erosion, infiltration, runoff and some soil properties. In order to ascertain how different soil surface conditions affect soil moisture regimes under semi-arid Mediterranean climate, a long term plus a specific experiment were designed in SE Spain (Almería, Rambla Honda field site).
The specific experimental design consisted in the monitoring during 9 months, by means of SBIB (self balanced impedance bridge) probes, a series of micro-plots over gravely sandy loams (mica schist), with very low contents of organic matter, calcium carbonate, and soluble salts, with a poorly developed structure. Four soil surface conditions are representative of most surfaces in this semi-arid landscape: A: well developed gravely pavement, underlayered by a sieving crust, formed after the agricultural abandonment. B: sealing crusts, found at the surface when runoff and rainsplash wash away the gravely pavement. C: litter and quite abundant annual plants, found under the canopies of bushes and shrubs; D: tilled soil, found prior to seeding, usually cereals. Micro-plots consisted in PVC cylinders of 25 cm diameter driven 20 cm into the soil. Soil moisture probes were set at depths of 2.5 cm, 5 cm, and 10 cm and connected to data loggers averaging and logging continuous measurements every 30 minutes. Sequential wetting-drying cycles were accomplished by irrigation (simulated rainfall) performed every 10 days, allowing the soil to dry out naturally.
The data from a long term monitoring program in Rambla Honda were also available, under natural rainfall, and with surfaces mostly corresponding to the types A and C previously mentioned.
Upon irrigation, or large rainfall events, all treatments always reach saturation, which are different depending on the soil depth. Most dry out curves are very steep during the summer (from 0.35 to 0.07 L/L in less than 24 hours). The steady water content is also different for the four treatments, following a decreasing order A, D, B, C. Surfaces with litter and annual plants are the second slowest in loosing their water content, just after the tilled surface, because of their mulching properties, however they steadily retain the smallest amount of soil moisture because of the consumption by annuals. Gravel pavements and tilled surfaces are those conserving the most soil water.

Key-words: soil moisture, crusting, stony cover, infiltration, erosion.

Session: *Development of Modelling Approaches, Databases and Maps*

Land use and sustainability evaluation in Mediterranean area by using hydrological erosive model: an example from central Italy

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Abstract

In Italy land resource management is becoming an important issue especially in areas affected by natural hazards such as soil erosion. The sustainability of a certain land use depends strongly on understanding and evaluating the interrelated factors influencing soil erosion. In such a complex natural system context the quantitative study of processes, such as for instance soil erosion, need appropriate instruments and methods. In this paper the hydrological-erosive model WEPP (Water Erosion Prediction Project – USDA) is applied with some differences related to management input file, compared to the original version. The results are calibrated by using ground truth as direct observation of sediment yields computed on a sub-catchment basin scale. Two sub-catchments of the Arno River were chosen as test areas located on the western slope of the Montalbano chain in central Tuscany. Soil losses have been examined on a hilly area, where Plio-pleistocenic deposits are prevalent. Such sites are representative of lithology, vegetation and climatic conditions of the Mediterranean areas where soil conservation problems are rather relevant. Furthermore, at this site intensive agriculture is associated with traditional crops such as vineyards and olive groves.
The comparison between measured and computed data allow us to identify those parameters that have the most influence on model behaviour. Once the model has been calibrated on the input data from the experimental sites the results obtained show a considerable amount of annual soil erosion, above the threshold allowed for such soils. Current land management results as the most important factor in soil loss, as it doesn't take into account soil fragility and climate aggressivity. Such conditions are not sustainable over a long time period and indicate that appropriate agricultural practices for soil conservation have to be adopted.

Key words: Erosion, modeling, land management.

Modelling soil hydrology in vineyard

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Abstract

An experimental study was carried out in a vineyard grown on a leached soil (ALFISOL) near Cavaion (moraine arc of the Garda lake, Verona, Northern Italy).
The aim of the work was to assess the soil hydrology in the unsaturated zone, by physical measurements, and its prediction by mathematical modelling. The soil selected is a Typic Hapludalf clayey loam, mixed, mesic.
Field data were taken by five tensiometers located at different depth (30, 50, 65, 100 and 120 cm, respectively) in the soil profile. Two mathematical models were applied to simulate data referred to the same soil parameters. The LEACHW is a richardian model generally applied to simulate hydrodynamics of soils cultivated under maize, while the CAVAION-GARDA is a combined "hydrothermic" model in which the equation of the transient water flux is integrated with the thermic flux one.
The input for both the models is given by daily values of air temperature, relative humidity and precipitation equally distributed over 24 hours.
Implements to the model are given by physical and chemical soil characteristics, and by the phenological stages of vineyard.
Comparing tensions measured in the field to the LEACHW simulation, it appears that this model amplifies soil wetting and drying cycles, with special reference to the zone with the maximum root concentration (50 cm depth). Conversely, the calculated hydric balance is substantially correct.
The CAVAION-GARDA model response seems to reproduce better the variability of the soil potential at different depths in time, and approaches well experimental data, with special regard to the winter period, when the reduced vegetal activity influences hydrology to a lesser extent.
The intercalibration of field data and computer simulation, including model implementation, allowed to underline the influence of the vegetal cover on the water hydrodynamics throughout the soil. Both the models proved very sensitive to the variability of the spatial distribution of the root system of the vineyard on the water movement.

Key words: soil hydrology; simulation model; soil-plant relationships.

Multi-criteria evaluation of conservation strategies for restored soils

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Abstract

Sustainable soil management entails the restoration of land that has temporarily been used as construction or exploitation sites. In many cases the restoration and the subsequent management results in compaction damage and water logging. Both reduce physical soil quality for agricultural land use and restrict soil management practices.
The execution of the Swiss soil protection legislation aims in the application of feasible restoration techniques and management practices for the subsequent land use, which support an ecologically sound development of the restored soil. However, there are different stakeholders involved in land restoration (farmers, soil protection authorities, restoration enterprises) and their objectives (high crop yield, soil conservation, low restoration costs) often are in conflict. In addition, there is a lack of methods for the assessment of the resulting physical soil quality.
To overcome these problems, we establish a multi-criteria evaluation system for land restoration. It assesses restoration alternatives in respect of ecological and economical criteria that represent the different objectives of the involved stakeholders.
Our multi-criteria evaluation system for land restoration consists of the following steps:
Objectives: Definition of restoration goals of the stakeholders on the basis of their land use intentions.
Alternatives: Identification of restoration and management practices and their costs. Establishment of causal relations between the applied restoration and management practices and the induced changes in soil physical properties.
Criteria: Generation of ecological and economical evaluation criteria with respect to the objectives of the involved stakeholders. Determination of criteria values of the alternatives.
Aggregation and Evaluation: Establishment of utility functions for all the considered criteria. Aggregation of the ecological criteria within a physical soil quality index. Evaluation of the performance of different restoration and management alternatives according to the achieved physical soil quality and the resulting costs.
The evaluation system is applied on a recently restored test site in Switzerland. Several physical soil indicators (bulk density, penetration resistance, macroporosity, saturated hydraulic conductivity, precompression stress) and the applied restoration and management techniques have regularly been monitored on the test site for two years. The data and the evaluation results of the test site are presented. The application of the multi-criteria evaluation system in general and of the soil quality index in particular is discussed.

Use of a Geographical Information System for selection of tillage systems contributing to rational soil management and prevention of soil degradation

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Abstract

Tillage systems mostly used at present in Romania are the conventional ones, and they are differentiated according to requirements for surface drainage and/or for deep loosening. In some particular cases specific tillage systems are recommended, as for sandy or for salt-affected soils. Recent research has shown that non-conventional, conservation tillage systems are suitable for many Romanian soils. A methodology for recommending soil tillage systems most adequate to different soil and land conditions has been developed (Canarache a. Dumitru, 1991). Required input data refer to soil texture, slope, waterlogging hazard, subsoil compaction, and salinity. Most of them are available in the GIS, and the waterlogging hazard which is not there may be estimated using a simple pedotransfer rule.

Soil and land resources of Romania may be represented at the scale of 1:1,000,000 in a very general way as microzones, defined by climate (5 classes), relief (.. classes), and soil genetical type (.. classes). There are ca. 100 oro-pedo-climatic microzones, some of them spread in different locations, with a total of more than 400 mapping units (Florea et al., 1988). A GIS with this information is now available (Munteanu a. Zota, 1994), including the climate, relief, and soil attributes mentioned earlier. Layers for various soil and land properties, as texture, gleying, salinity etc. have been introduced at different stages, and other layers are considered to be introduced.

The present paper describes pedotransfer functions developed to estimate some of the attributes needed for tillage system evaluation not included in the existing database, namely slope gradient, waterlogging hazard and subsoil compaction. The procedures used to recommend soil tillage systems, and the way these procedures are making use of the GIS are presented. This GIS makes use of the ARC/VIEW software and of a current IBM-compatible personal computer. A general map of Romania with the results of this procedures, as well as the area of arable land suitable for various tillage systems, is included.

Prediction of tensile stresses with hydraulic models

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Abstract

Cohesive soils underly swelling and shrinking processes when wetted and dried. Volume change due to water loss results eventually in a separating of subvolumes from each other along a plane of greatest weakness due to tensile stresses. This behaviour in cohesive soils is partly desired, e. g. in agriculture, as it will form structures and aggregates and has in general positive benefits under ecological perspectives, i.e. improves mechanical stability and water and gas flow. However, structure formation is partly as well disliked when soil is used e.g. as a mean for encapsulation of landfills. Here, it is required to gain high stability and low permeabilities with decreasing matric water potentials.
The shrinkage behaviour is often described by water content-void ratio relationships. However, these relationships do not take into account the state variable matric potential, which is the primary reason for the build up tensile stresses as can be derived from the Terzaghi-equation for unsaturated soils.
In the paper a method is presented, which enables the direct determination of tensile stresses which is usually problematic due to volume changes during the drying process and hence change of the water retention curve. An exact assignment of the matric water potential and tensile stress is then not possible. The presented method keeps the soil volume constant under swelling and shrinkage conditions and allows the measurement of the matric potential, swelling pressure and degree of saturation at the same time. Based on theoretical considerations a model for the prediction of tensile stresses has been developed based on a hydrological model. This model is experimentally validated by known methods for the determination of hydrological characteristics through the multistep outflow experiments.
The results show, that the tensile stress can be calculated using the water retention characteristic. As part of the Terzaghi-equation the □-factor could be determined.
This knowledge of the value of tensile stress as a function of the matric water potential is very useful for the approach of predicting structure formation.

Key words: tensile stress, matric water potential, water retention curve

A neuro-cognitive model to forecast pollutants flow-transport in unsaturated zone

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Abstract

Researches about pollutants diffusion in unsaturated zone have showed several difficulties for carrying out an accurate model. Actually one-dimensional flow transport models have underlined many limits. Particularly in absorbiment studies of nutriments this class of models has pointed out a underestimate in zone near to surface ground, because it doesn't consider longitudinal dispersiveness of pesticides that are used from garden centres. Studies have showed that flow – transport equations of water – pollutants describe inadequately phenomenon for following reasons: drying up causes wide fissures that control type of flow; absence evaluate of pesticides gaseous phase. Moreover initial and boundary conditions, putting in the model, don't agree with realty because chemical and hydraulic propriety of soil can vary, in a non-linear way, both spatially and temporally; so it becomes difficult their characterisations. Models accentuate these limits when they are applied to small areas like in studying case.
Application of bi-dimensional models has allowed greater connections with environmental realty, but it has involved considerable problems to data handling. In several cases it has resulted hard to apply these models in consequence of large territorial and geological data that need. Recently, in the sector of environmental modelling, new computing methodologies were applied using Artificial Neural Networks (ANN) that are particular computational structures for numerical elaboration. ANN can quantify complex phenomena, for which classic mathematical models don't consider too many quantities that likewise influence studying phenomena. In other words, after learning phase using example data, ANN are able to map relationships between phenomenon and quantities that influence it.
In this research it shows a flow – transport model, based on ANN, of pollutants in unsaturated zone that it allows a most accurate management and conservation of vulnerable esteemed aquifers. Study, calibration and validation of the model was done in Pistoia plain where several garden centres are located. These garden centres guaranteed an optimum covering of land with many and various cases and also effective collaboration.
The results, obtained using ANN, have showed a good forecasting of pesticides diffusion in unsaturated zone of ground and they have allowed a best knowledge of some parameters influence on phenomenon.

Key words: artificial neural networks, mathematical models, flow-transport, pistoia plain.

Modelling rainfall erosivity: the case for Ethiopia

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Abstract

Rainfall "erosivity" is the most influential and varying factor that needs to be determined in the quantification of soil erosion. Methods are developed to identify the best descriptive index and determine erosivity values for other Ethiopian Meteorological Service stations where currently, only less detailed rainfall records exist.

Various rainfall unit kinetic energy and erosivity calculation models were examined under the Ethiopian rainfall distribution for the soil erosion data of six to fifteen years. Detail rainfall, runoff, and soil loss data from six research units located in different ecological zones of the Ethiopian highlands were used to verify the effectiveness of various erosivity models. Correlation coefficients between erosivity indices - calculated using various erosivity models - and soil loss from different plot scales were used to compare the descriptive ability of those erosivity models under the Ethiopian rainfall – soil loss relationships.

The results of the statistical analyses showed that the Hudson (1986) unit kinetic energy model was better correlated to soil loss at all the six research units studied compared to the Wischmeier and Smith (1978) model. But, the differences were statistically significant at Andit Tid research unit only. The Brown and Foster (1987) model, on the other hand, had an intermediate correlation with soil loss compared to the Wischmeier and Smith (1978) and Hudson (1986) models. Comparison of the performances of the erosivity indices recommended by those authors, however, showed a non-significant difference ($P>0.05$). Yet, the Brown and Foster erosivity index had a superior correlation with soil loss at the majority of the research units studied followed by the Hudson erosivity ($KE>10$) model, modified for the Ethiopian conditions.

Regression coefficients between the best descriptive rainfall index and readily available rainfall parameter (monthly rainfall, in this case) were also calculated to check whether a single equation holds for all the research units, located in different ecological zones, examined. The analysis of the regression coefficients, however, showed that the differences between the regression coefficients were statistically significant at 5% significance level. Nevertheless, grouping regions with similar annual distribution of monthly rainfall improved the relationship between monthly rainfall and erosivity and the same equation also held describing the variation in rainfall erosivity for the regions with similar rainfall distribution. This study has exhaustively examined the applicability of various unit kinetic energy and erosivity models at various regions of the country. Therefore, the results should improve prediction of soil-loss and facilitate proper planning and implementation of soil conservation practices.

Key words: Erosivity, soil erosion, soil loss, soil degradation

Evaluation of moisture characteristic models and estimation of hydraulic functions for a heavy clay silt soil in Khuzestan, Iran

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Abstract

Unsaturated flow in porous media is described by Richards equation. In order to use this equation, hydraulic conductivity function has to be specified. Brooks-Corey, van Genuchten and van Genuchten Mualem,s method have been used for the determination of this function for a silty clay loam soil in Khuzestan. For this purpose undisturbed samples from the top soil of a field plot was collected in metal cylinders for the determination of soil moisture characteristics, on sandbox tensiometer and in pressure plate apparatus. RETC program has been used for the derivation of the parameters of van Genuchten equation. Results were compared with those obtained using simple less costy methods like Saxton,s (1986), Gregson (1987) and Huston and Cass (1987). Huston and Cass method gave more accurate results while Gregson,s model were not reliable at high pressures. Using a single point determination at 63 cm suction provided satisfactory results with Gregson,s model. Saxton,s model using only soil texture data produced acceptable regression at high suction. This last method has been compared with Guelph permeameter results for the determination of saturated unsaturated hydraulic conductivity function in a series of field experiments. Results were promissing especially due to low cost and availability of large database on soil texture.

Modelling the dynamic evolution of gullies in a semiarid catchment of Swaziland (Southern Africa)

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Abstract

Land resources management is becoming an important issue in regions affected by natural hazards. The sustainable development of land resources is depending on the understanding of the processes and dynamics active within the landscape. In southern African countries soil erosion and the related problems like water quality issues or decreasing soil productivity are the main topics affecting the inhabitants of rural and urban areas. Therefore the problems related to soil erosion were more and more focused in the recent past. This can be also documented by a increasing number of erosion studies and the development and application of erosion models. Nevertheless gully erosion phenomena have been completely neglected in erosion modeling . Thus because the development of erosion models was focused on regions with intense agriculture of developed countries on the one hand and because of the spatial and temporal heterogeneity of gully erosion processes on the other. This study regards the identification of spatially distributed erosion forms and processes in the Mbuluzi-river catchment (Kingdom of Swaziland). Particular attention was focussed hereby on the gully erosion phenomena. The following modeling of the gully erosion was done successively with models accounting for the two developing stages of a gully. The physically based static and dynamic gully models (SIDORCHUK 1996, 1998a,b, 1999) were therefore applied. The input data were obtained by remote sensing techniques (API method) and GIS-analyses. The example from Southern Africa show that the methods applied are able to identify areas affected by gully erosion. Furthermore it is possible to estimate the amount of soil loss due to gully erosion, which is not taken into consideration with the USLE-type models.

Prediction accumulation of chemical matters in the surface layers of soils under evaporation from the surface of ground-water

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Abstract

Ecological imbalance is one of the most important Global problems recently. This is highly related to reclamation, conservation and productive use of soils. Environmental conservation requires many studies on the effects of pollutants on soils. Scientific methods should be applied to reclamation of polluted soils due to high agricultural practices, excessive pesticide and fertilizer use. In a "water-soil-plant-atmosphere" ecological system, predicting and estimating soil pollution using mass transfer theory is an important problem today. As known, radioactive and industrial waste, lack of technique and process in petroleum industry cause soil pollution which affects on physical, chemical, and biological reactions in soil system. Therefore mass transfer mechanism in a soil ecological system is destroyed and then soil fertility decreases, erosion increases. Mass transfer between soil solution and solid phase (anion-cation) is obstructed. Generally, changes in soil physicochemical properties are determined by studying on transfer mechanism of chemical matters in soil to prevent pollution in a soil ecological system.
In this study to determine the soil pollutants movement, a mathematical model was solved to define diffusion and mass transfer of dissolved chemical matters in heterogeneous porous media from soil surface to a given depth of L. Distribution of pollutant concentration along a soil profile and degree of soil pollution can be predicted by using the solution of the model.

Key words: pollutants, migration in soil, estimating, mathematical modeling

Sustainable soil loss and hazard evaluation in a Mediterranean fragile area using hydrological erosive models and GIS techniques

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Abstract

The main purpose of this work is to characterise landscape evolution as a function of the parameters that influence soil loss, especially in areas where shallow and weak soils are present.A considerable amount of studies have been carried out on the problem of soil loss and the mechanics of water erosion are rather well understood and documented. The basic processes of soil erosion, including the principles of control and prevention, are commonly and schematically identified as follows: detachment of particles by raindrops falling on a bare soil, development of runoff on a slope with transportation of particles either previously detached or scoured by water shear stress and outwashed from the slope. In taking into account these considerations the basic factors affecting soil loss by water are: erodibility of the soil, climatic aggressiveness (rain erosivity), morphology, land use and management.
A research project dealing with land management and, more in detail, a study of soil degradation in a particularly fragile Mediterranean area (Sardinia), is here presented. The research work, by evaluating the morphoevolutive trend and in particular the soil erosion process, derives indicators to be used for a better soil erosion hazard evaluation and for sustainable soil management. The experimental area is located in Sardinia, where the geology is characterised by a complex situation with a prevalence of metamorphic rocks. The climatic conditions are represented by high intensity rainfalls concentrated in the rainy season, with a quite low annual amount. With these climatic and lithological conditions, the pedogenetic processes are rather slow and the resulting soils are consequently thin and weak.
The erosive phenomena, which generally take place on these soils, present a relatively low absolute value which is however quite important compared to their sustainable productivity. In this specific situation the accuracy in measuring and forecasting soil loss for different scenarious results of paramount relevance in soil conservation practices management.
Soil loss evaluation has been determined at plot scale by means of rainfall simulations, at slope scale by using hydrological erosive models and at basin scale by using both models and experimental data obtained from a sediment load measuring station located on an instrumented catchment. The hydrological erosive model employed in this research work was the WEPP (Water Erosion Prediction Project). This model allows one to compare computed soil loss and experimental data obtained both by simulated rainfalls and sediment load in the river. The use of the WEPP model consented to analyse several characteristics of the considered soil. In fact one of the relevant elements which allows us to validate such hydrological model is the comparison with experimental data. This procedure provides the possibility of identifying those natural components to which the model is very sensitive. Once the components are identified and evaluated model calibration proceeds and the phase of regionalization can start.

Validation of RUSLE and EPIC models for predicting soil losses from wheat crop rotations in South Portugal

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Abstract

The empirical model RUSLE and the semi-empirical model EPIC were validated to predict soil losses in South Portugal. 20 years data from 8 cropped erosion plots and 5 years data from 4 bare soil plots were used. Crop systems are 2-year rotations wheat-fallow and wheat-cover crop (legume).

Appropriate results for RUSLE are obtained when detailed soil data on the plots are used, including the rock fragments fraction, and when average data for the period in analysis are adopted referring to the 2-year duration of the rotation.

Adequate results for EPIC are obtained when fisrt the runoff component is calibrated. Runoff is described by the SCS curve number method and infiltration is computed with the Green-Aumpt equation. Erosion is simulated with the MUSLE equation. Therefore, the USLE factors validated for RUSLE are used in the EPIC model. Results for EPIC are also analysed for the 2-year duration of the crop rotations.

Results presented show main results for the validation of both models, comparing simulated vs. observed data. An analysis comparing both models and the respective predicting capabilities for erosion and runoff (in case of EPIC) are finally presented.

Pedological information management for the european project of soil cartography at 1:250.000 scale

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Abstract

The European Soil Bureau project of a European soil map at 1:250.000 scale has to face a number of unsolved problems which range from the homogenisation of the national data to their management by means of adequate databases and GIS applications. In Italy the project of the 1:250.000 soil cartography is already starting in some of the major <*Regioni*> of the country. Unfortunately the problems deriving from heterogeneous survey procedures and from the substantial absence of an adequate and easy-to-use database are still present. The solution of the first problem will be suggested in a short lapse of time by the reports of the "Metodologie Pedologiche" Project of the <Ministero per le Politiche Agricole e Forestali>. This project is introducing new codes and new survey devices that will have necessarily to be adopted by Italian <*Regioni*>.
In this paper we present a solution to register and to manage pedological data by means of an original software application, developed with *Microsoft Access 97*, that we called *ESBase*. This application presents the characteristics of a typical relational database and offers several advantages and new conceptual solutions in the field of *GIS-pedological database* systems:

- It is in conformity with the database structure recommended by the European Soil Boureau (Finke et al, 1999) and can register datasets concerning soil regions, soilscapes, soil bodies, pedological observations, horizons and laboratory results;
- It can manage the new code system recommended by the European Soil Bureau and by the "Metodologie Pedologiche" Project special commission (Carnicelli et al, in print);
- It is based on a semplified Entity-Relation conceptual model and it uses only simple relational links (one-to-one and one-to-many relations);
- It introduces a partially new code system that allows to univocally identify observations and datasets;
- It can easily link data to map units joining the codes of the tables in the GIS systems;
- It works on every PC and notebooks thanks to the low amount of system resources it requires. It is free and, above all, it is easy to use. The latter characteristic derives from the simple entity-relation model it is based on. The users can also introduce the information at the detail level they want without compromising the system stability.

Key words: database, GIS, cartography

An Information system for soil protecting use of forestry machines

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Abstract

The use of wheeled and tracked machines is a common and broadly accepted practice in European forests. The mechanized activities of such machines compromise a broad range of different operations, like plantation (mainly tractors), harvesting (mainly harvesters and forwarders) etc. However, all of these operations can cause severe soil damages. In order to avoid those, an information system is introduced, which gives the forester a clear indication, whether a specific machine can be used without causing such soil damages.
The two main factors, which must fit for an ecologically sound machine operation are

- machine configuration, and
- soil stability.

The mechanical impact to soil and its structure depends from the machine and its tyres or tracks, respectively. For a wheeled machine the important factors which control the energy input, are wheel load and dimension, its type and inflation pressure. For a tracked vehicle only the machine weight and track dimension are used to estimate the applied energy so far.
The ability of soil to carry a certain load without being affected in its internal physical structure, depends primarily on soil type and soil water content. In addition the amount of skeleton, humus and clay plays an important role for the bearing capacity, too. Only the soil moisture content is highly variable, whilst the others can be regarded as constant for a specific site.
Part of the information system are databases with technical information about market available machines, tyres and soil characteristics of site classes, respectively. By means of an user defined selection of machine, tyre and site class, the programme is capable to compute a so called "maximum tolerable water content" up to which a designated vehicle can operate on the site without causing soil damage. Such kind of information enables a forest practitioner either to postpone the operation to an appropriate time in terms of soil water content or to carry out the operation on an alternative site matching the demand. He also can reconfigure the machine with better tyres or a lower inflation pressure until its modified ground pressure meets the bearing capacity of the soil.
The importance of such a tool lays in two facts:

- It is easy to handle, very transparent and a fair instrument combining soil physical and equipment based information.
- This leads to a sustainable forestry in respect to soil protection.

Key words: soil protection, forestry, information system, forest machines, forest tyres

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