Wind Erosion in the central Ebro Basin under changing Land use Management. Field Experiments with a small portable Wind Tunnel.

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Summary
The process of wind erosion is very slow and subtle. Therefore its amount is often highly underestimated compared to that by water erosion. It is important for environmental planners and other stakeholders to evaluate the relationship between agricultural land use and these two erosion processes. In particular the influence of extensification on the quantitative relationship between water and wind erosion is not well understood. To add more quantitative data to the evaluation process, a recently developed small portable wind tunnel has been used during two field campaigns in the central Ebro Basin. Quantitative findings in this field study indicate that the sediment output on undisturbed, crusted soil is negligible compared to that of disturbed soil surfaces. Besides rolling the research suggests that sheep trampling combined with wind causes relatively high amounts of sediment loss by wind erosion.

1 Introduction
Since the 1990s an increasing area of the central Ebro-Basin is experiencing an ongoing land use change towards extensification. The two main reasons are the low profitability of the commonly used dry farming system and the large set-aside programs which are subsidised by the European Union. Following this change from arable to fallow land the relative importance between the two main processes which increase desertification in this semiarid region – wind and water erosion – are changing significantly.

For example the sediment loss from ploughed fields through water erosion is almost negligible while sediment loss by wind can reach high amounts. On the contrary, wind erosion on surfaces with physical soil crusts is insignificant compared to very high sediment losses due to water erosion. The main objective of the field research at Mariá de Huerva (Zaragoza, Spain) was therefore, to determine which process causes most of the soil degradation under which land use management.

2 Materials and Methods
2.1 Wind tunnel
A small, portable wind tunnel was used to conduct 42 wind erosion test runs. The wind is generated by a fan with 5.5 hp, 163 cm³ and a two wing propeller. The wings can be variably adjusted to different angles to change both the wind power and wind speed. The test runs were done with an average wind speed of 8 m/s for a time period of 10 minutes. The turbulent rotating air stream is caught by a 2 metre long transition section which consists of strong PVC-foil with a thickness of 1 mm. The frame of the honeycombed air straightener and the wind tunnel each have a diameter of 70 x 70 centimetres (H x W). The honeycomb structure of the air straightener is made of 15 cm long and 4 cm wide PVC tubes. The 3 metre long tunnel itself consists of
three separate (1 m long) sections of aluminium and perspex sheets which can be folded up for transport. The sheets are stabilized and connected by three aluminium frames. The bottom of the tunnel is open and creates a 2 m² test area. The sediment output from the test area is caught by the sediment catching area which is made of usual canvas cover (tarpaulin) with a base of 3 x 5 meters and vertical boundary’s of 1 m (side) and 1.5 m (back) height. An overview of the wind tunnel is shown in photo 1.

![Photo 1: Build-on wind tunnel in María de Huerva, Spain](image)

2.2 Soil surface treatments

The soil surface treatments ploughing, harrowing and rolling were chosen to imitate the typically applied dry farming system in the Ebro Basin. During the fallow stage farmers first plough and harrow their fields to increase the infiltration of rainwater and then roll their fields to seal the soil surface against evaporation loss. This system is applied during fallow season to store more water within soil for the next growing season.

Additional to the runs on arable land, tests were carried out both on fallow undisturbed and crusted soils and on soils which had been disturbed by simulated sheep trampling.
3 Results

![Mean Sediment Output](chart.png)

The results from the wind tunnel tests on different soil surfaces in María de Huerva are shown in figure 1. Tests on undisturbed, crusted soil surfaces (Column 1) show almost no sediment detachment through wind erosion. The sediment output increased significantly from 0.40 g to 1.4 g when the soil crust has been partially destroyed by simulated sheep trampling (Column 2). The observed soil loss, due to sheep trampling during a wind event (Column 3), was more than 15 times higher than that on undisturbed crusted soil. Surprisingly the amount of wind erosion on ploughed (Column 4) and harrowed fields (Column 5) was much lower than that caused by sheep trampling during wind events. By far the highest sediment output was found on rolled fields with more than 20 g (Column 6).

4 Discussion

The sediment output by wind erosion on undisturbed, crusted soil is almost negligible. Due to generally high silt contents of about 50 % (SEEGER 2001) soil surface sealing and fixing of fine soil particles occur frequently. Therefore this result corresponds with our expectations and the results from previous studies of HUPY (2004) and RAJOT, ALFARO, GOMES & GAUDICHET (2003). Remarkable is the relatively big difference between the different sheep trampling simulations. Although the soil crusts were clearly destroyed in both simulation processes, the soil loss in the scenario combining sheep trampling with wind is more than four times higher than in the scenario without simultaneous wind simulations. It seems that not only the destruction of the crust is responsible for the increase in soil detachment. Probably more important is the uplift of loosened particles into the moving air stream.

Although our soil roughness measurements with the chain method after SALEH (1994) show a decrease in surface roughness from ploughed to harrowed and rolled, the sediment loss from column 4 to 6 increases exponentially. Research from DÜWEL, SCHÄFER und
KUNTZE (1994) shows more linear increasing trends. An explanation for this phenomenon could be that the micro topography, which is created by soil aggregates and can’t be measured with the chain method, acted as shelter for smaller particles. Therefore the increase from ploughed to harrowed is not very significant.

The soil loss from rolled fields reaches quantities similar to the amount of particle output through water erosion on crusted soils in the Ebro Basin (RIES, LÄNDER & REHBERG 2000; RIES & LÄNDER 2002).

5 Conclusion

There are four main conclusions from this experimental research:

1. Wind erosion on abandoned crusted soils is negligible compared to that by water erosion.
2. Crust destruction can result in the formation of soil Aggregates which are too big for detachment by pure wind force and therefore create shelter for smaller particles.
3. Agricultural land use is not necessarily increasing soil erosion by wind. Only the management rolling definitely creates highly susceptible surfaces to wind erosion.
4. Intensive sheep grazing should perhaps be limited to periods with low wind velocities to minimize soil loss by wind erosion.

Even if this fairly simple wind tunnel is not able to simulate all of the aerodynamic parameters which are necessary to represent exactly the natural wind conditions, the mobility together with the capability to produce verifiable data from different surface conditions recommend its utilisation. With further research we hope to increase the amount of quantitative data demonstrating the relative importance of wind and water erosion in rural semi-arid regions with changing land management systems.

References


