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Impact of black locust hedgerows on wind velocity and wind erosion in Eastern Germany

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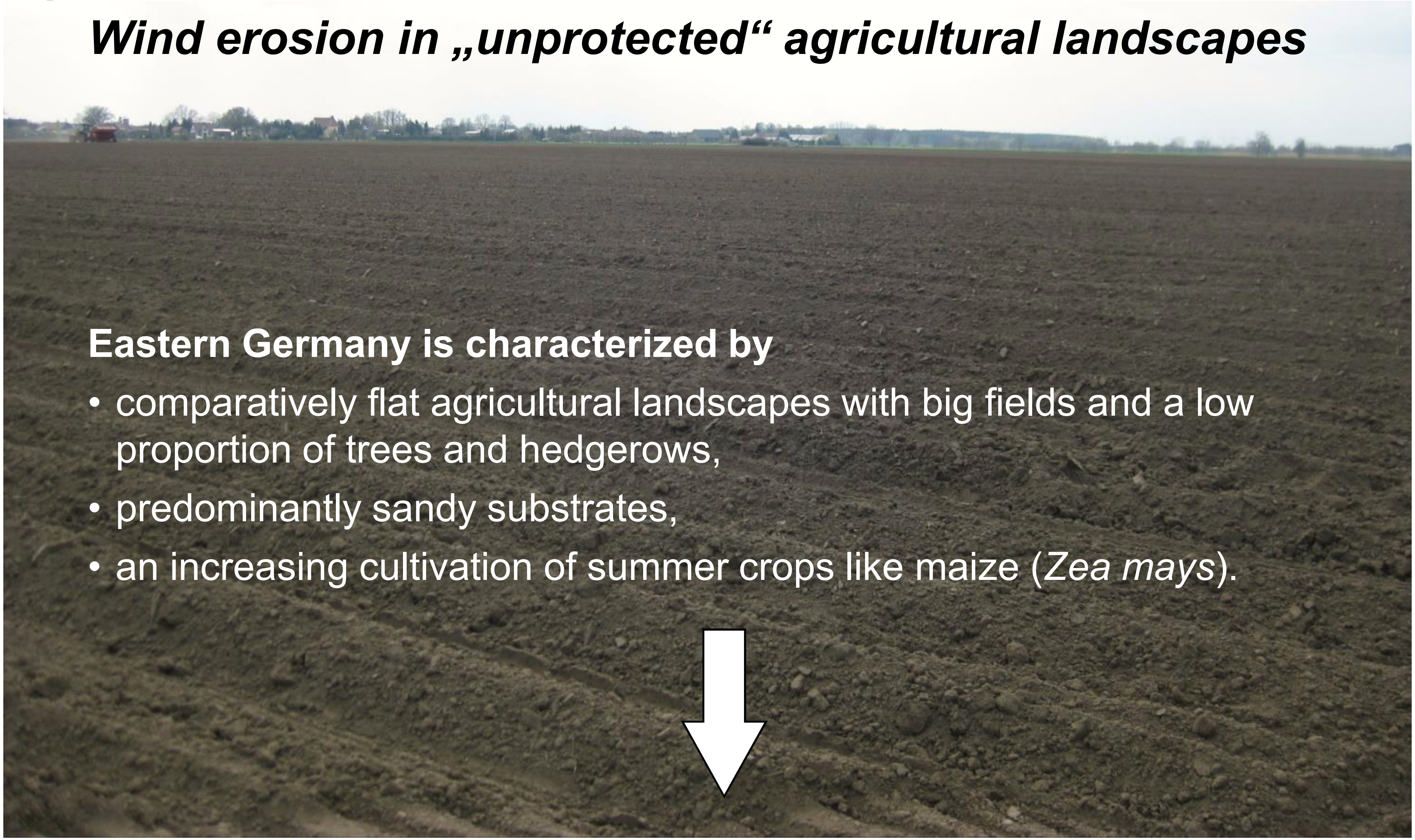
Wind erosion in „unprotected“ agricultural landscapes



Eastern Germany is characterized by

- comparatively flat agricultural landscapes with big fields and a low proportion of trees and hedgerows,
- predominantly sandy substrates,
- an increasing cultivation of summer crops like maize (*Zea mays*).

Wind erosion in „unprotected“ agricultural landscapes

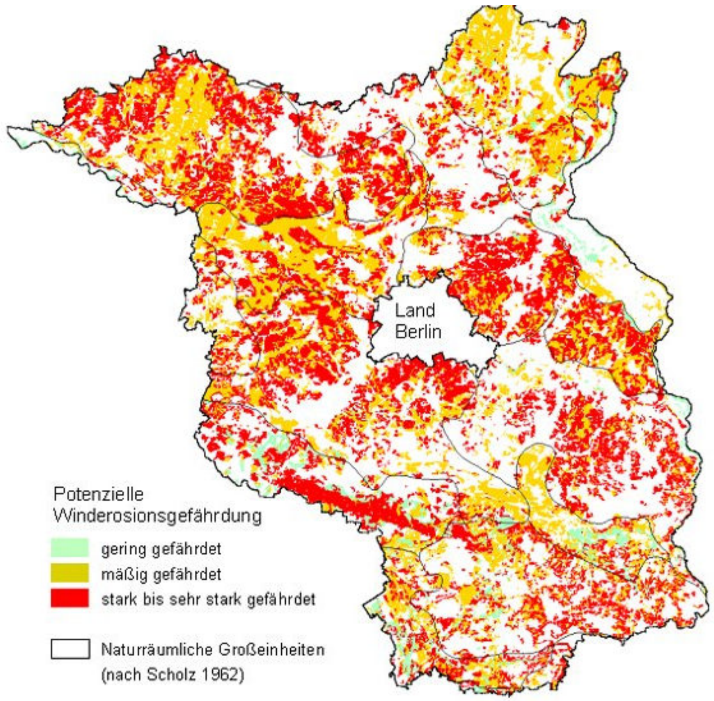
In this region:

- Soils are susceptible to wind erosion
- In Brandenburg State a major part of agriculturally used areas is potentially threatened or even highly threatened by wind erosion

- Wind erosion is one of the most important reasons for soil degradation.

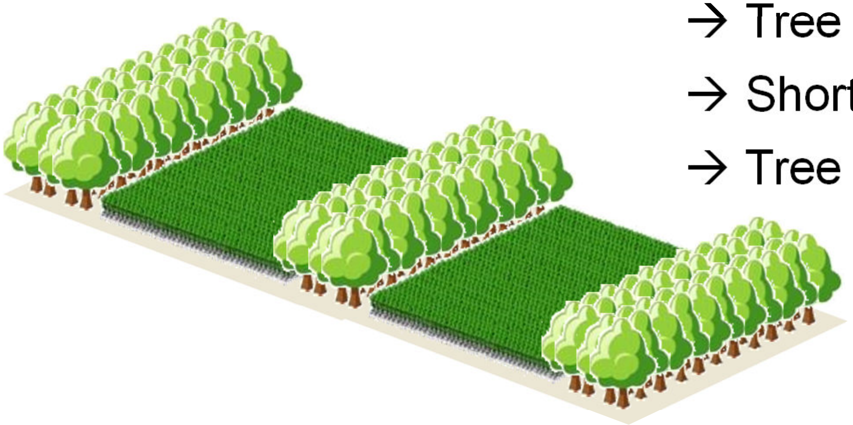
Source: Maik Veste, 2011

Risk of wind erosion in Brandenburg



Source: Frielinghaus et al., 1994; LUGV, 2008

Agroforestry with fast growing trees



→ Alley cropping

→ Tree species: poplar, willow, **black locust!**

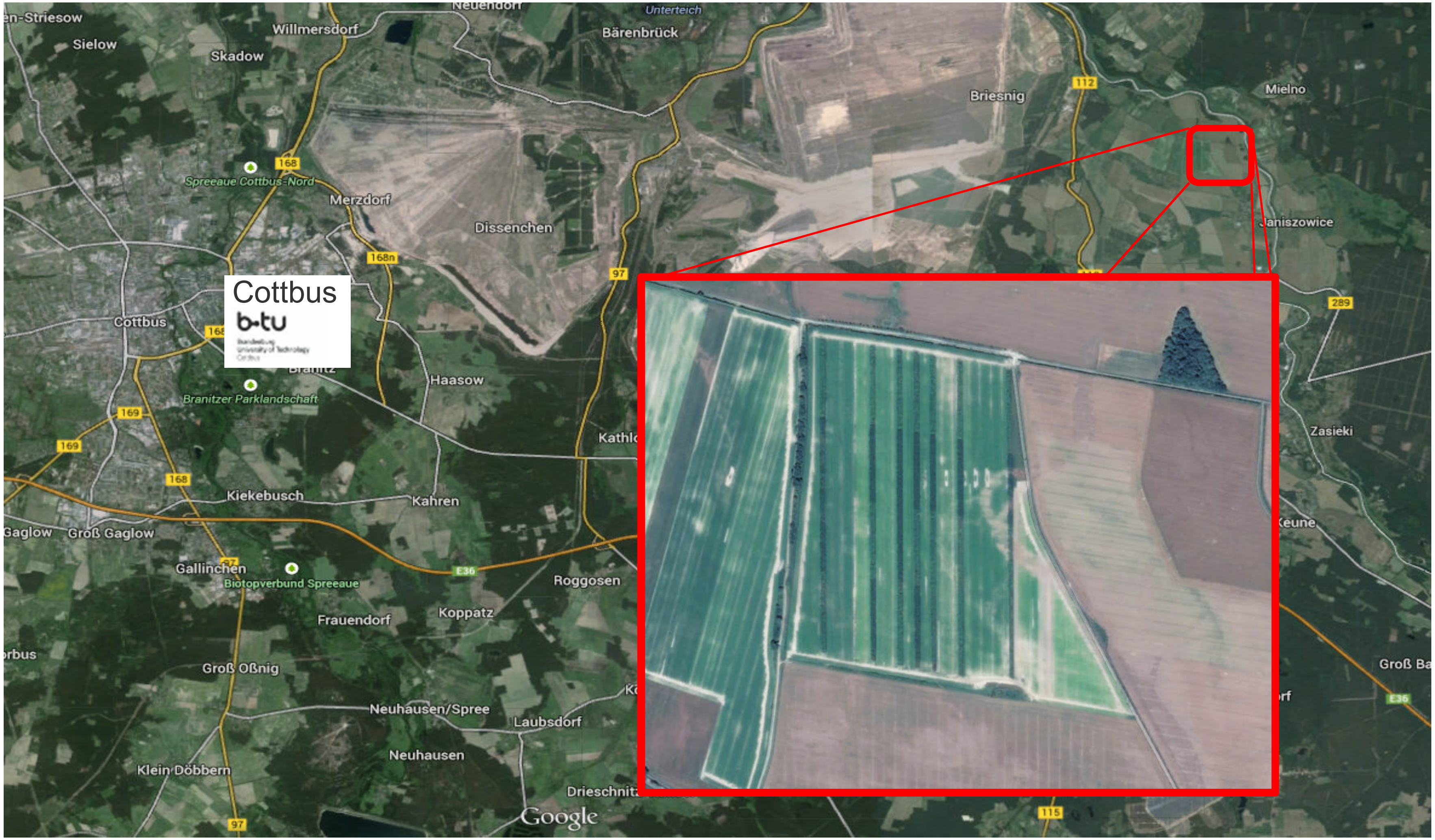
→ Short rotation periods: < 20 years

→ Tree height << 8 m

Question

Do what extend short rotation alley cropping systems can act as effective wind breaks and hence contribute to soil protection against wind erosion?

Location of study site



Characteristics of study site

Site Characteristics

- Located in a naturally formed, flat landscape dominated by agriculture
- About 600 m away from the river „Neiße“
- Mainly sandy loams and loamy sands
- groundwater varies between 1 and 2 m below the soil surface
- Total area: 40 ha

Alley Cropping System

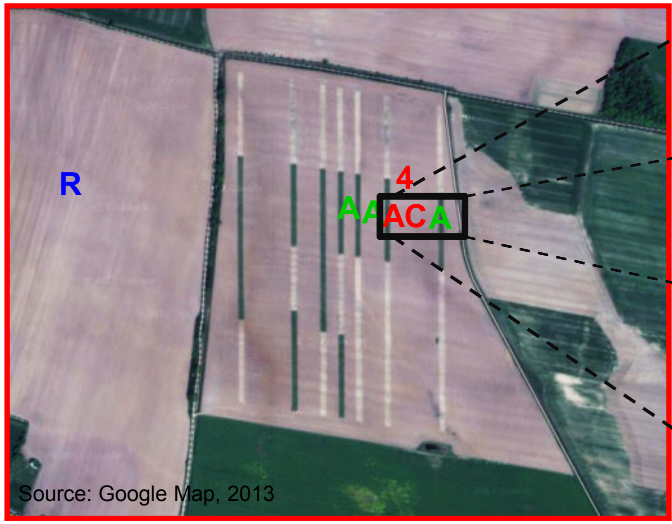
- established in spring 2010
- **Tree hedges:** North-South direction; width = 10 m; alternate poplar (Max) and **black locust** (250 m segments); 4 double rows (8700 trees ha^{-1} tree area);
  rotation period: 5 years (up to now not harvested)
- **Crop alleys**: different widths = 24 m, 48 m and 96 m; lupines, potatoes

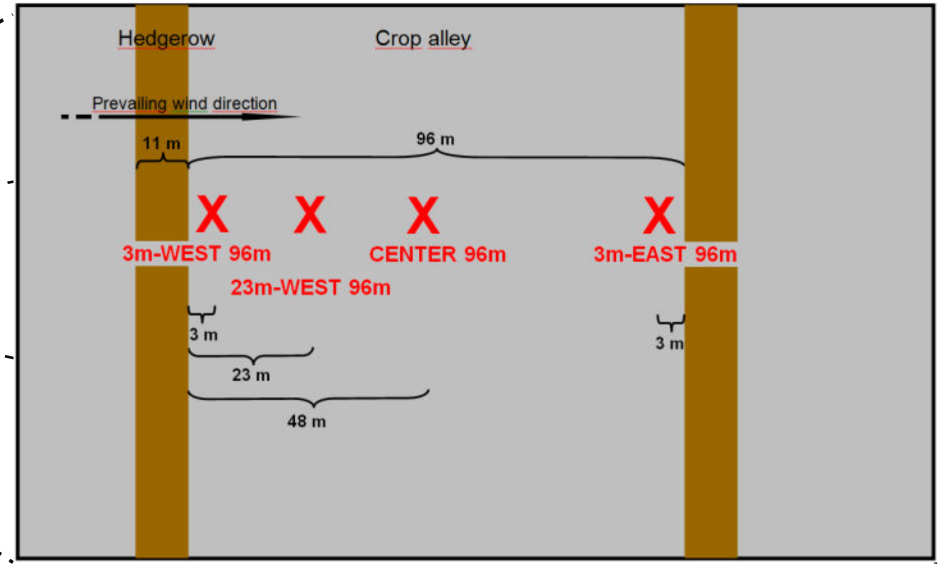
Experimental design at study site

4 AC = 4 anemometers at a 96 m wide crop alley
[3m-WEST 96m; 23m-WEST 96m; CENTER 96m; 3m-EAST 96m

A = 2 additional anemometers at the center of a 24 m and a 48 m crop alley
[CENTER 24m; CENTER 48m]

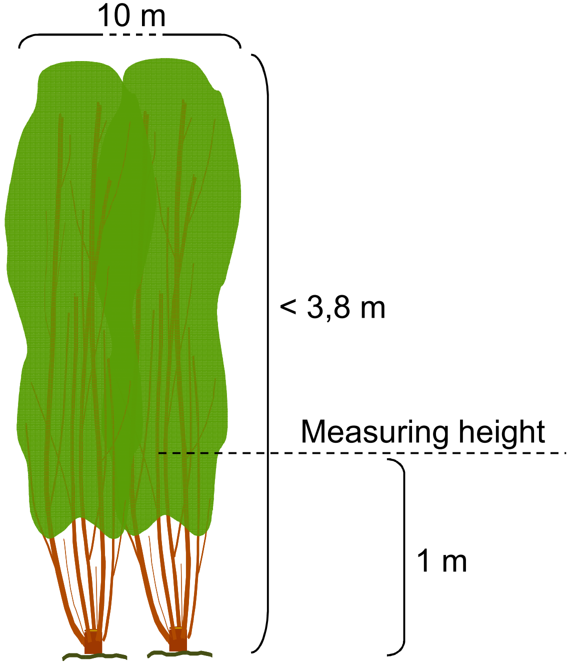
R = Anemometer at the open reference field [REF]





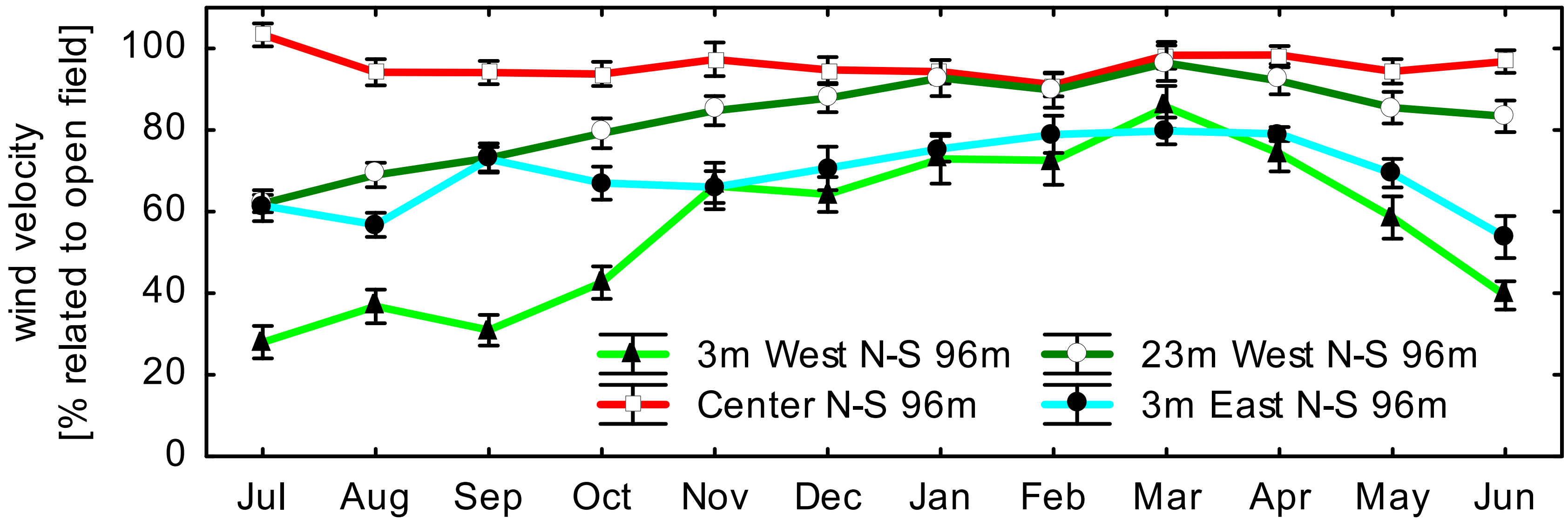
Microclimatic measurements

- → Wind velocity was measured from July 2012 to June 2013 by data loggers (Delta-T devices);
- → Wind speed values were recorded continuously and averaged every 10 minutes
- → Measurement instruments (A100R, Vector Instruments) were installed 1 m above soil surface



Wind velocity – differences along a 96 m crop alley

INFO: measuring period: Jul 2012 to Apr 2013; monthly averages with standard errors; Ø tree height: 3.15 m



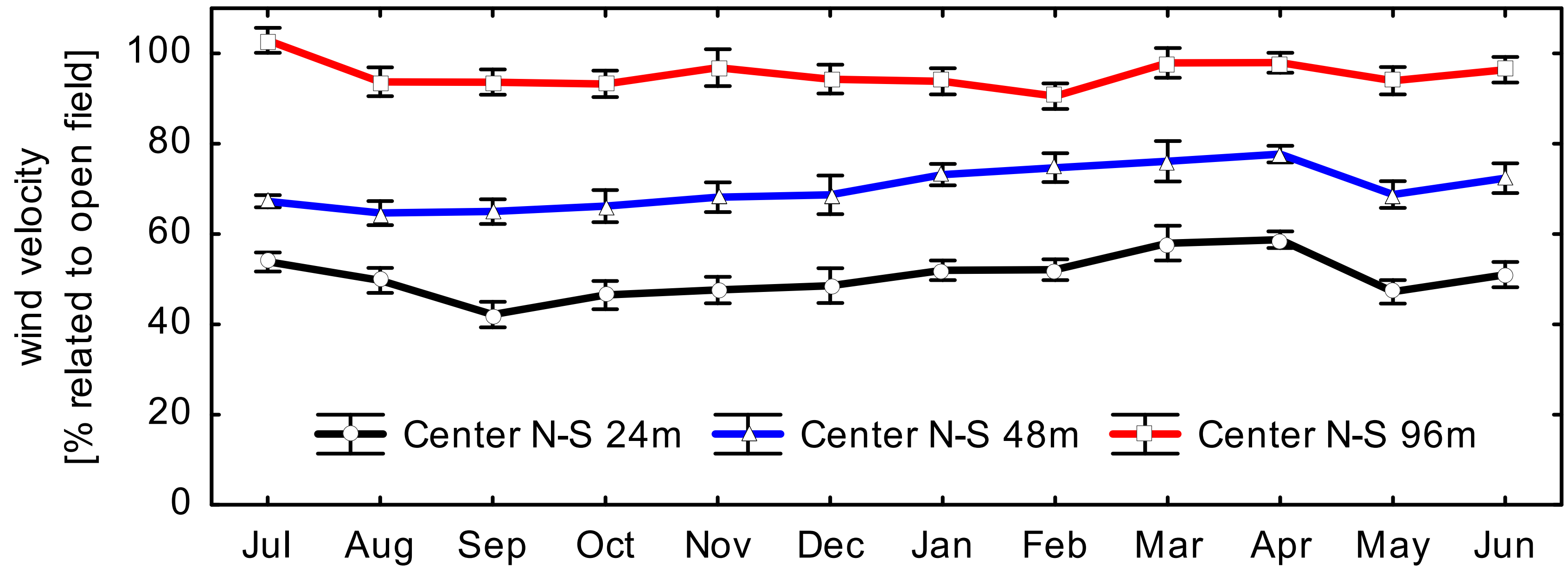
Ø Wind velocity in % related to the open field:

3m West: 56   23m West: 83   Center: 96   3m East: 69

Source: Böhm et al., 2014

Wind velocity – impact of the width of the crop alleys

INFO: measuring period: Jul 2012 to Apr 2013; monthly averages with standard errors;
Ø tree height: 3.15 m



Ø Wind velocity in % related to the open field:

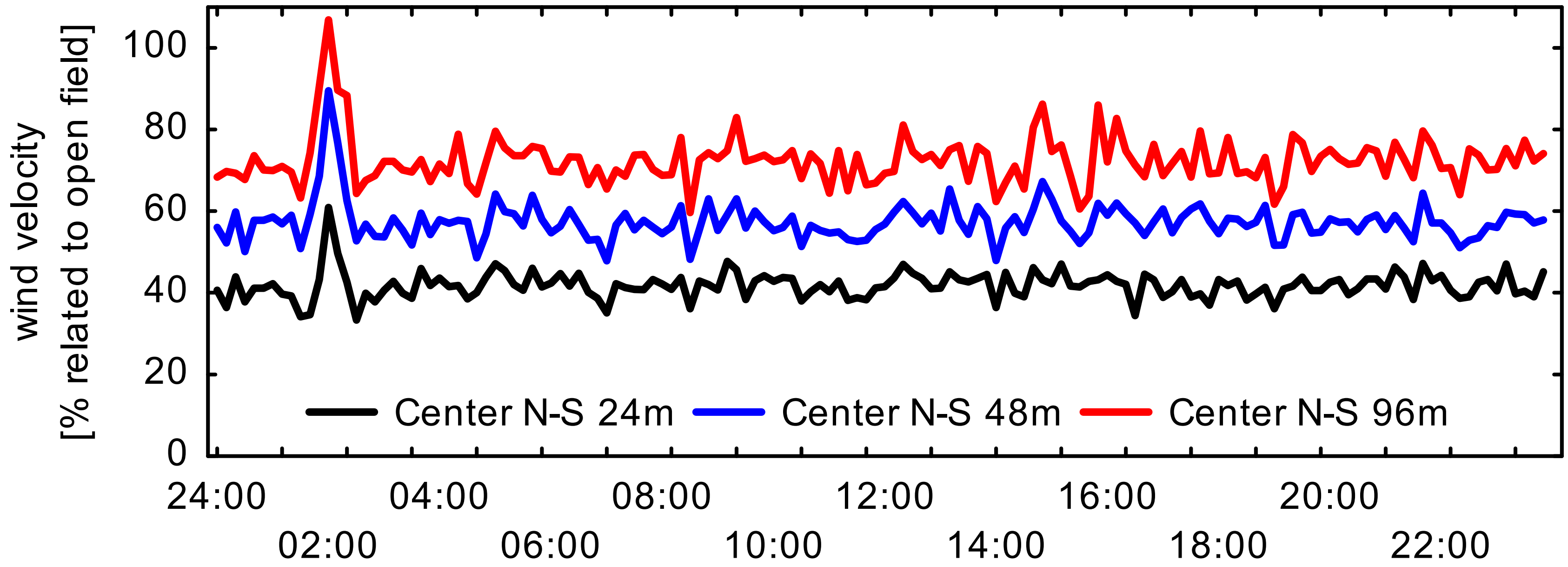
Center 24m: 51 **Center 48m: 71** **Center 96m: 96**

Source: Böhm et al., 2014

Wind velocity

– impact of the width of the crop alleys on a windy day

INFO: measuring day: 31th of January 2014; Ø tree height: 3.15 m

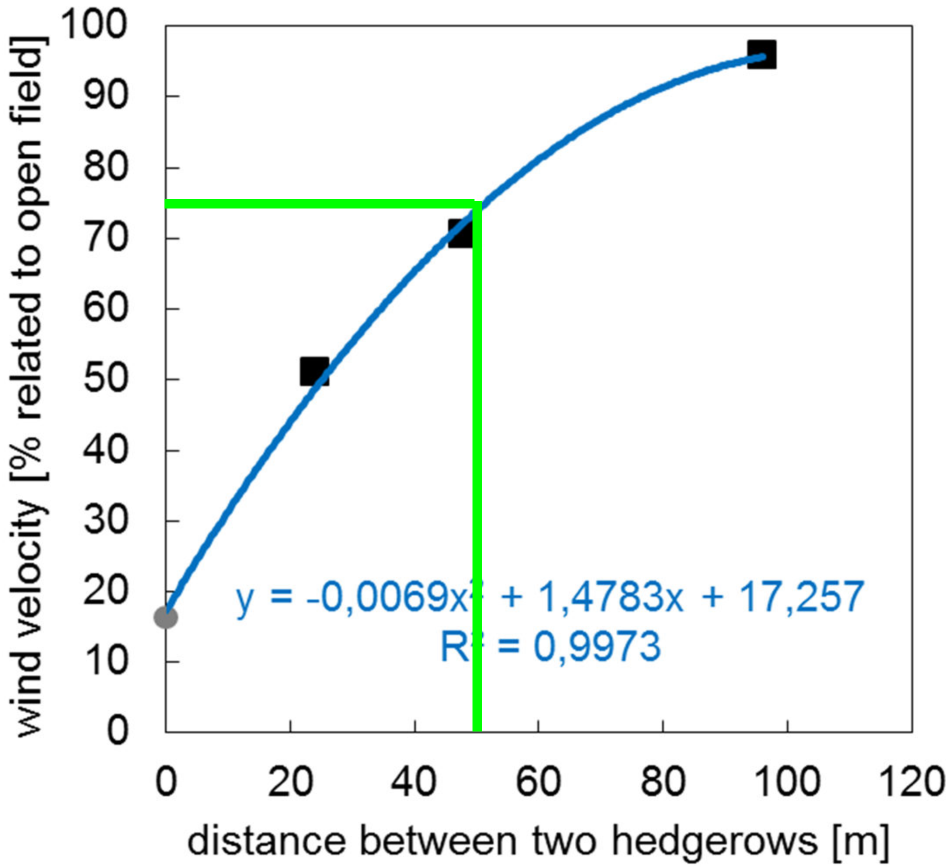


Ø Wind velocity in % related to the open field:

Center 24m: 42 Center 48m: 57 Center 96m: 72

Source: Böhm et al., 2014

Wind velocity – impact of the width of the crop alleys



- Polynomial relation
- Distance between 3 m high hedgerows should be not more than 50 m in order to ensure an average reduction of wind velocity of 25 %
- Short rotation alley cropping with 10 m wide hedgerows and 50 m wide crop alleys would have a proportion of tree area of 15 %

Source: Böhm et al., 2014

Wind velocity and erosivity

→ Potential for wind erosion is depending on the threshold friction velocity (TFV)

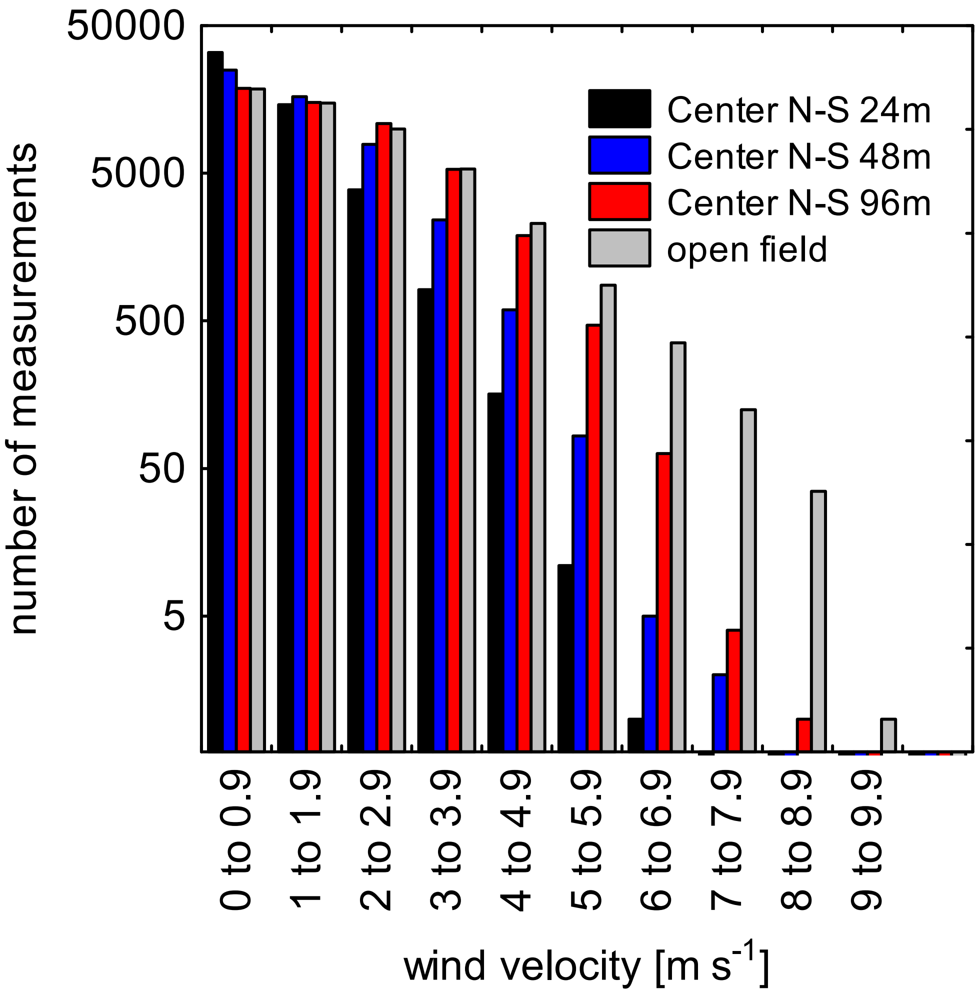
- → TFV is defined as the minimum friction velocity that is required to initiate movement of an aggregate or particle resting on the soil surface (Sharratt and Vaddella, 2012)
- → the higher the TFV is, the lower is the potential for soil particle moving; low TFV is typical for soils susceptible to wind erosion (e.g. sandy loams)
- → TFV is influenced by numerous factors such as soil texture, soil moisture, soil organic matter content and vegetation cover

→ Estimation of TFV for study area

- → TFV of 0.23 m s^{-1} can be assumed (according to Leys (1991) for similar conditions)
- → TFV of 3.6 m s^{-1} was calculated for 1 m above the soil surface (logarithmic equation for the vertical wind speed profile according to Sharratt and Feng (2009))

↳ In terms of the measured wind speeds 1 m above the soil surface a wind velocity of at least 3.6 m s^{-1} is required for moving soil particles and thus for beginning wind erosion process

Wind occurrences



- wind speed values equal or larger than

  3.6 m s^{-1} could be reduced in the center of crop alleys by **93 %**, **75 %** and **26 %** related to the open field when hedgerows have been planted every 24 m, 48 m and 96 m, respectively

  5.0 m s^{-1} by **99 %**, **94 %** and **61 %**

Source: Böhm et al., 2014

Summary

1) Generally, short rotation alley cropping systems (height < 4 m) result in a significant reduction of the average wind velocity

2) Reduction of wind velocity is higher at the peripheries of the crop alleys, especially at the western edge areas

3) Shelter belt effect generally increases with decreasing width of crop alleys

4) Wind peaks are also reduced considerably at crop alley widths of up to 100 m

5) Number of wind ocurrences with wind velocity higher than TFV can be reduced considerably with decreasing width of crop alleys

Conclusion

Short rotation alley cropping systems can be seen as promising option to prevent wind erosion

Width of crop alleys should not exceed 50 m for systems with hedgerows lower than 4 m, for wider crop alleys higher hedgerows are needed → longer rotation periods

Aside from erosion control, further positive effects for yield stability can be expected from wind reduction by short rotation alley cropping:

- lower evaporation,
- less wind damage on crops

However:

A greater appreciation of these benefits is needed in order to extend the establishment of this land use system.

Thanks for your interest

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VATTENFALL