Influence of rain distribution on yield and management practices for a winter wheat cultivation

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Abstract

For the development of management strategies for precision agriculture spatial site properties and temporal aspects have to be taken into account. This study shows the temporal influence of precipitation distribution on yield and nitrogen fertilisation efficiency from sites in a region with a negative seasonal water balance.

Introduction

Water is one of the most important factors for the crop growth. Precision agriculture strategies are mainly adjusted to the spatial variability of soil properties such as water storage capacity, texture, and relief. In regions with a negative seasonal water balance and fluctuating precipitation amounts and distribution, management strategies have to take into account this temporal variation as well as the spatial variation. This article describes a method to assess the temporal and spatial influences on yield pattern, and the effects of uniform fertiliser applications.

Materials and methods

The study was carried out in a field in Wulfen, Germany. Wulfen is situated in the Eastern part of Germany 100 km southeast from the highland ranges of the Harz. The average precipitation is about 450 mm per year; fluctuating from 250 to 620 mm. 12 monitoring sites were selected within a field with very heterogeneous loess soils and textures ranging from sandy to clayey loam. The relief consists of gentle slopes from North to South. At the monitoring sites the volumetric water content was measured with capacitance probes. To determine the plant development on the monitoring sites, biomass, growth stages and yields were monitored. Long-term weather data covering a forty-year period were obtained from a nearby weather station. The soil water balance, weather and crop data were used as input for the modelling package DSSAT (Decision Support System for Agrotechnology Transfer, IBSNAT, 1999). A bio-indicative model (Selige *et al.*, 2001) was used to classify zones with width of 50 mm available water storage capacity of the root zone AWCrz to transfer the point data into area. The N-efficiency was determined using an empirical approach.

Results

Figure 1 shows the spatial distribution of grain yield and nitrogen efficiency of the farm standard nitrogen application rate (180 kg N ha^{-1} yr^{-1}). Average grain yield was 4100 kg ha^{-1} (ranging from 1100 to 6500 kg ha^{-1}). The average N-efficiency was 58%, fluctuating between 12 and 90%.

Figure 2 shows the simulated grain yield distribution (as index) at the monitoring site number five for a thirty-year period from 1969 to 1999. Average grain yield over the period was 4100 kg ha^{-1}, ranging from 1300 to 6600 kg ha^{-1}. Efficiency of the standard N-application fluctuated between 19 to 92 % with an average of 58 %. These results clearly show that the development of precision agriculture strategies in regions with a negative seasonal water balance has to take into account the temporal variation of precipitation as well as the spatial heterogeneity of soil properties. The fluctuation of yield and N-fertilisation efficiency in the given example indicates the need for management approaches containing risk assessment strategies for yield expectations and nitrogen fertilisation.

References

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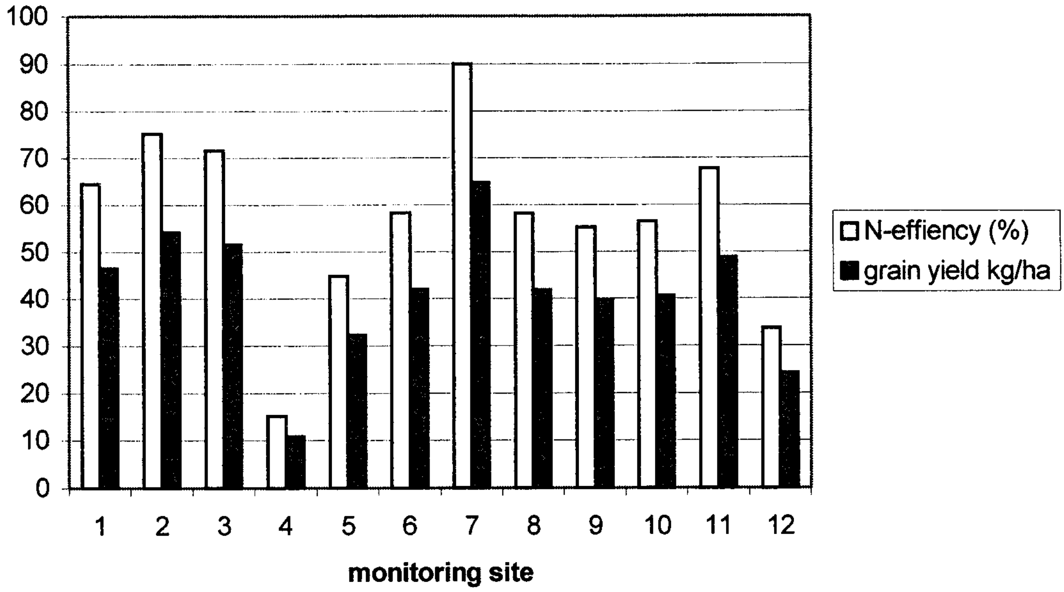

Figure 1. Spatial yield distribution and N-efficiency on 12 monitoring sites in Wulfen

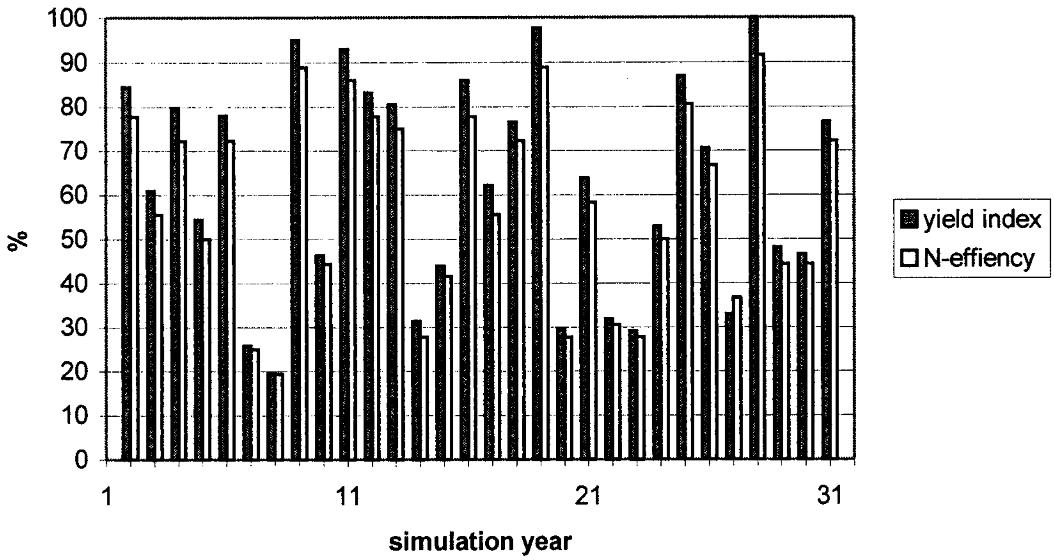

Figure 2. Timely yield distribution and N-efficiency on monitoring site five in Wulfen