EVALUATION OF THE SPATIAL VARIABILITY OF SEED YIELD AND ITS APPLICATION TO THE IMPROVED USE OF NATURAL RESOURCES AND INPUTS IN OILSEED RAPE PRODUCTION

HANEKLAUS, S., RÜHLING, I., SCHNUG, E.

Institute of Plant Nutrition and Soil Science, Federal Agricultural Research Centre Braunschweig-Völkenrode, Bundesallee 50, 38116 Braunschweig, Germany

ABSTRACT

The spatial variability of parameters of soil fertility is reflected by variation in yield. The availability of yield sensors in combination with the *Global Positioning System* (GPS) provides the possibility to measure and locate yield differences within the field. Equifertilies - zones of equal yield potential can be derived from the exploitation of yield maps collected over several years and used for a sustainable input of resources. The *Local Resource Management* (LRM) concept of agricultural soils uses these techniques for the optimisation of inputs and soil protection.

INTRODUCTION

Farming on ecologically sound way benefits from tools for the recording of the spatial variability of parameters of soil fertility. The on-line measurement of yields simultaneously with positioning by GPS is a technology which provides information about the spatial variability of yields within the field. The available yield sensors measure yields either volumetrically or by means of radiation via flow density. The advantages of each system are summarised by Murphy et al. (1995). The exploitation of yield maps produced over several years enables the evaluation of equifertiles, which are essential for the establishing of *Digital Agro Resource Maps* (DARM) which contain geocoded information of optimised use of natural resources and inputs (Schnug et al., 1993).

RESULTS AND DISCUSSION

Oilseed rape is known as a crop with a high compensation ability and variability of yields can be related to the variability of parameters of soil fertility. The results presented here as an example for oilseed rape mapping are derived from an oilseed rape crop grown on a marsh soil in Northern Germany (Figure 1B). The yields were determined by means of the *Claydon*-yieldometer system in combination with a GPS system. Devices for yield mapping are now commercially available but still need some skill to deliver valid information. More details about yield mapping are provided by Murphy et al. (1995).

The generation of yield maps involves first the calculation of observed variograms which represent the progressive change of yield along specific directional orientations. In Figure 1A the variability between yield data points along a 60 degree bearing with a distance increment of 15m is shown. For the oilseed rape field an exponential model with the nugget effect (variability of yield data at distances less than the sampling interval) suppressed gave the closest relationship (R=77%) between distance among data points and variability of yield. The range gives information up to which distance yield data are spatially related to one another and thus can reflect the variability within the field. In the example given in Figure 1A the range on the major axis was ≈90m.

Marsh soils are among the most productive but the variability of yield is as high as on other soils (Figure 1b). The average yield level based on the interpolated data was 3.6 t ha^{-1} with a minimum of 2 t ha^{-1} and a maximum of 5.5 t ha^{-1}. Limitations in oilseed rape yield were closely related to the silt content of the soil which restricted plant available water. Other growth factors such as the supply with nutrients were sufficiently supplied for the realisation of maximum yields.

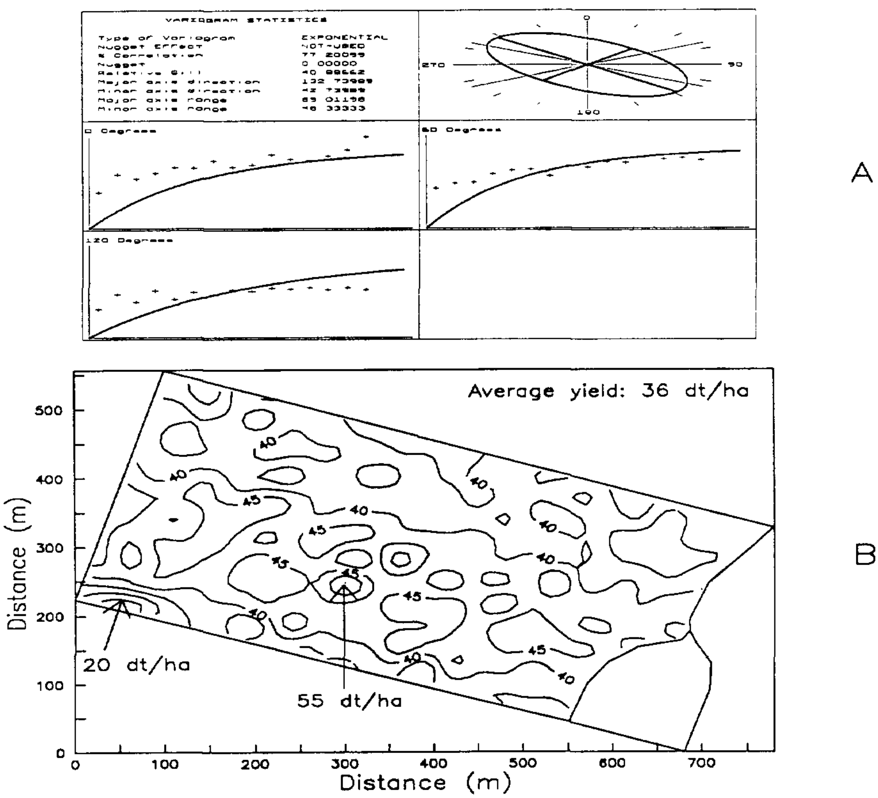

FIGURE 1. A Variogram for oilseed rape yield on a Marsh soil
B Spatial variability of oilseed rape yields on a Marsh soil

An important nutritional factor influencing the interpretation of yield maps is the sulphur (S) nutritional status of the oilseed rape crop. Severe S deficiency became one of the most widespread nutrient disorders in North-European agriculture lowering the yield potential by up to more than 50% (Schnug and Haneklaus, 1994). Low average yields due to severe S deficiency could be misinterpreted as restricted productivity of the field with consequently lower necessary input of resources so that the evaluation of the S nutritional status is particularly important for oilseed rape production. Because variations in the S supply are closely related to soil texture (cp. Schnug et al., 1995) yield differences in oilseed rape fields without S supplied express variation of soil texture and soil water dynamics in the soil and offer information of immense value. This information will deliver the basis for optimised soil sampling and S fertiliser strategies and can moreover be integrated into other fertilisation models (e.g. nitrogen).

One-year yield maps (cp. Figure 1) reflect external factors that determined the yield at different locations of the field and can be used e.g. for the calculation of nutrient removals or the co-ordination for managing soil sampling choosing zones of low, medium and high yields.

The collection of yield maps over several years allows the evaluation of equifertiles i.e. zones of equal soil fertility (Schnug et al., 1994). This will help to sort out the causality of yield differences. Two principal causes are possible: first the yield limiting determinant is a variable factor which can be improved by agrotechnical procedures or secondly it is a permanent factor and thus cannot be influenced. Each measured parameter is interpolated in order to get an overview about the spatial variability in the field and saved in DARM´s. Each DARM is stored in the *Local Resource Information System* (LORIS), where DARM´s can be combined according to verified algorithms thus producing a DARM which contains geocoded instructions for the use of natural resources respectively application of inputs. By means of variable rate spreader systems combined with GPS the task is then carried out in the field. Depending on the nutrient, inputs often can be reduced by more than 30%.

For example an optimised S fertiliser strategy for oilseed rape shall be described. DARM´s which contain information about the spatial variability of the following parameters are requested: yield and soil texture. These data are evaluated by MOPS, a MOdel for the Prognosis of S-deficiency (Schnug et al., 1995) resulting in a spatial application map which regulates the amount of S fertiliser according to crop demand and soil parameters.

The results reveal that the utilisation of the *Local Resource Management* (LRM) concept is an important step towards a more sustainable agricultural production technique, not only in oilseed rape cropping. Within *LRM* the geocoded registration of yields is a central point which gives information about the variability of yield potentials in the field and which can be used for the control of varied inputs of resources.

REFERENCES

Murphy, D., Schnug, E. and Haneklaus, S. (1995): Yield mapping - a guide to improve techniques and strategies. *Proc. Workshop Soil Specific Crop Management, ASA-CSSA-SSSA, Madison*

Schnug, E., Murphy, D., Evans, E. and Haneklaus, S. (1993): Local Resource Management in computer aided farming: A new approach for sustainable agriculture. *In: Fragoso, M.A.C. and Beusichem, M.L. van (eds.), Optimization of Plant Nutrition,* p.657 - 663, Kluwer Acad. Publ. Dordrecht

Schnug, E. and Haneklaus, S. (1994): Sulphur deficiency in Brassica napus. Biochemistry, Symptomatology, Morphogenesis. *Landbauforschung Völkenrode* SH 144

Schnug, E., Haneklaus, S. and Murphy, D. (1994): Equifertiles - an innovative concept for efficient sampling in the local resource management of agricultural soils. *Aspects of Applied Biology* 37, 63 - 72

Schnug, E., Bloem, E. and Haneklaus, S. (1995): Significance of soil water dynamics for the sulphur balance of oilseed rape. *This volume*