Increasing corn (Zea Mays L.) profitability by site-specific seed and nutrient management in Igmand-Kisber Basin, Hungary

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Abstract. *Variable Rate Technology (VRT) in seeding and nutrient management has been developed in order to apply crop inputs variably. Farm equipment is widely available to manage in-field variability in Hungary, however, defining management zones, seed rates and amounts of nutrients is still a challenge. An increasing number of growers in Hungary have started adopting precision agriculture technology; however, data on profitability concerning site-specific seeding and nitrogen management is not widely available. The objective of our work and this paper was to investigate the effect of variable rate seeding and nutrient management in a 92-hectare field planted with corn (Zea mays L.) where site-specific management had not been applied earlier. Management zones, seed and nitrogen variations had to be defined for the first time in the experimental field. Based on long-term remotely sensed data, 3 ha average management zones were determined for soil sampling. After sampling and laboratory analysis, seed rate and nitrogen recommendations were given to the farmer. Seed rates were determined based on the hybrid potential as well as the experience of the grower in the investigated location. Variable rate seeding was carried out by means of a John Deere 1775ND 12 row planting machine. Seed rates were determined between 65 and 82 thousand seeds per hectare. VRT nutrient management was limited to differences in nitrogen head fertilizer only, as soil sampling was carried out in the springtime. Variable rate nitrogen fertilizing was carried out by means of a Kverneland Exacta TL Geospread machine. The head fertilizing rate varied between 80 and 140 kg per hectare of carbamide. Despite dry climatic conditions with no precipitation in the optimal time period, yield and profitability increased. Lack of precipitation limited the efficiency of the variable rate nitrogen head fertilizing, however, all 34 management zones produced a profit in the experimental field.*

Keywords. *Site-specific seeding, site-specific nitrogen management, profitability of corn (Zea Mays L.) production*

Introduction

Precision farming aims to handle heterogeneities within a field, attempting to take into account the requirements of the plants as well as the environment. Thus, site-specific agricultural systems are geared toward large-scale farming, increasing its existing production advantages (Auernhammer et al. 2001).

Variable Rate Technology (VRT) in seeding and nutrient management has been developed in order to apply crop inputs variably. Variable rate seeding (VRS) in corn (*Zea mays L.*) was investigated in the U.S Corn Belt between 1987 and 1996, with the objective to estimate the economic value to the farmer (Bullock et al., 1998). The study, where over 40 thousand research units were involved, found that the economically optimal rate in the Midwest Corn Belt was 67,900 plants ha^{-1}.

In order to apply variable rate seeding, there are four basic steps to be followed: first and foremost: management zones have to be identified. *Management zones* are well suited for locating benchmark soil-sampling sites. Small, spatially coherent areas within fields may also be useful in relating yield to soil and topographic parameters for crop-modelling evaluation. Stafford et al. (1998) used fuzzy clustering of combine yield monitor data to divide a field into potential management zones. Management zones are usually based on soil types or yield maps proceeding from several years of data (preferably from similar plants), or general knowledge of yield or any other within-field differences (Gili, 2017). Management zone analysis provides spatial information on within-field differences (Fridgen et al., 2003). Second, the *seed rate* has to be determined. A standard recommendation when VRS is introduced in a field is to decide on three to four seeding rates with a minimum three thousand seeds/ha difference. Once seeding rates are determined for each zone, a *prescription map* has to be created. As a final step, the prescription map has to be *uploaded into a variable rate controller*. The controller has to be calibrated and set for the required parameters, and finally has to be set to *record* as-planted information.

Farm equipment is widely available in Hungary to manage within-field variability, however, defining management zones, seed rates and the amount of nutrients - mainly nitrogen - are still a challenge. An increasing number of growers in Hungary have started adopting precision agriculture technology; however, data on profitability concerning site-specific seeding and nitrogen management is not widely available. The objective of our work and this paper was to investigate the effect of variable rate seeding and nutrient management in a 92-hectare field planted with corn (*Zea mays L.*) where site-specific management had not been applied earlier.

Materials and methods

The experiment was carried out near Székszend, Komárom-Esztergom County, Hungary. Geographically, the area belongs to the Igmánd-Kisber Basin.

Management zones, seed and nitrogen variations had to be defined for the first time in the experimental field. Based on long-term remotely sensed data, 3 ha average management zones were determined. Soil sampling route were calculated. (Fig. 1.).

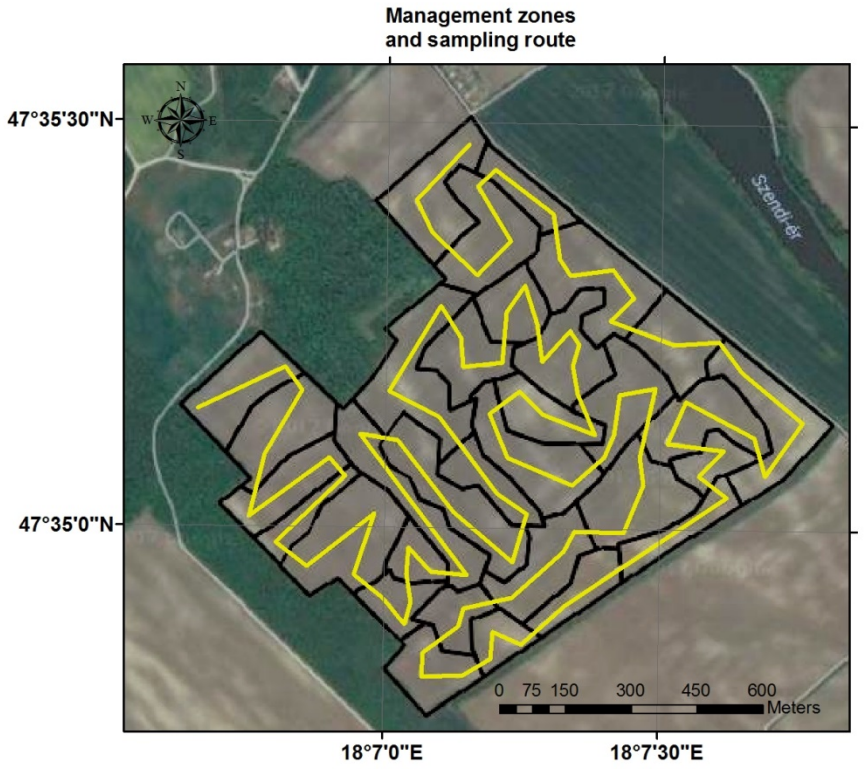

Fig. 1. Location, management zones and sampling route in the investigated field.

After sampling and laboratory analysis, seed and nitrogen recommendations were given to the farmer according to a 27-parameter (AgroAim) seed rate and nutrient recommendation system. Seed rates were determined based on hybrid potential (Dekalb, DKC 4025) as well as the experience of the grower in the investigated location. Variable rate seeding was carried out by means of a John Deere 1775ND 12 row planting machine. Seed rates were determined at between 65 and 82 thousand seeds per hectare (Fig. 2.).

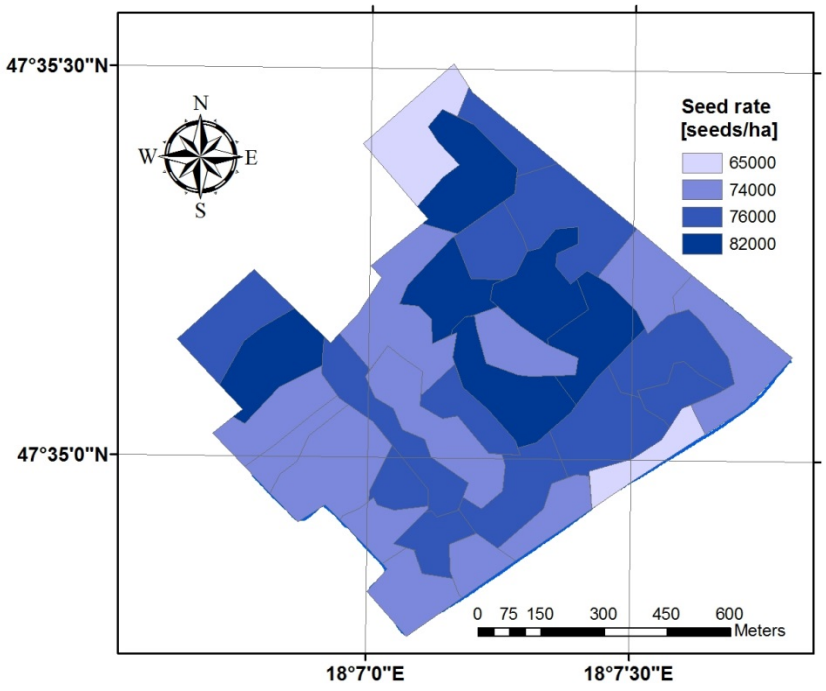

Fig. 2. Applied seed rate in the investigated field.

VRT nutrient management was limited to differences in nitrogen head fertilizer only, as soil sampling was carried out in the springtime. Variable rate nitrogen fertilizing was carried out by means of a Kverneland Exacta TL Geospread machine. The head fertilizing rate varied between 80 and 140 kg per hectare of carbamide (Fig. 3.).

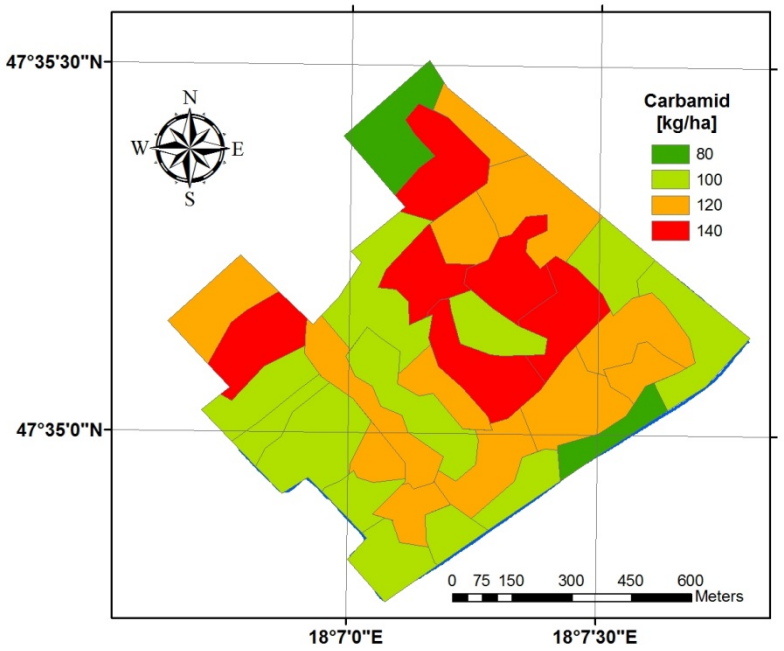

Fig. 3. Variable rate nitrogen head fertilizing amounts in the investigated field.

Immediately after application of the fertilizer, a Garford inter-row cultivator was applied in order to carry out mechanical weeding as well as mix the fertilizer into the upper level of the soil.
Yield mapping was carried out by means of a CASE IH 12 raw combine harvester, equipped with a yield mapping system. Expenses for the season were calculated for the farm level (Tab.1.)

Table 1. Expenses for corn production in US dollars at the investigated farm (calculations related to t/ha)

deep cultivation	76.90
soil sampling + advisory	13.50
seed-bed	30.80
seeding	25.00
seed	96.20
bacteria starter	41.50
fertilizer (uniform)	46.20
fertilizer (head fertilizer)	46.20
cultivation	26.90
plant protection	103.80
harvesting, yield mapping and transport	96.10
drying	97.00
Total	**700.00**

Results

Climatic conditions were not favorable in the investigated year, therefore, less corn was produced in the region than the expectable average. In the neighboring farms, the average yield was 7 t/ha, the site-specifically treated field produced an average of 9.8 t/ha. The yield data differed between 6.2 and 12.8 t/ha. Expenses and incomes were calculated for each management zone individually.

Despite dry climatic conditions with no precipitation in the optimal time period, yield and profitability increased. Lack of precipitation limited the efficiency of the variable rate nitrogen head fertilizing, however, all 34 management zones produced a profit in the experimental field (Fig. 4.).

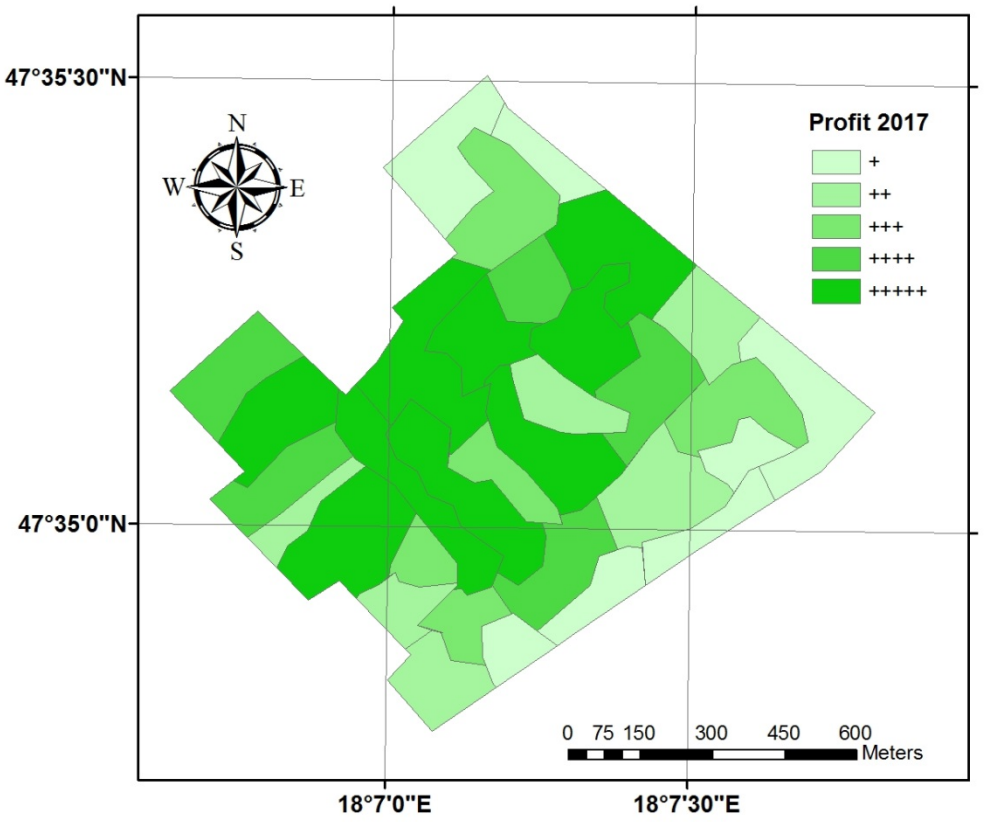

Fig. 4. Profit map for the investigated field.

Summary

A farm level experiment for corn (*Zea Mays L.*) was carried out in Szákszend (Igmand-Kisber Basin), Hungary, in order to investigate the profitability of site-specific seed and fertilizer application. Variable rate seeding and head fertilizer (carbamid) was applied in the 34 management zones in a 92 ha field. Calculations proved that despite the unfavorable climatic conditions (lack of precipitation), all management zones produced a profit in the investigated year.

Acknowledgements

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