What to choose towards economic sustainability? – Site specific weed management

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Sustainable agriculture – means to use several old and new farming methods. Less importance goes to the economic sustainability: how the farmer should produce to be viable, to earn enough net income. The aim of this paper to show those crucial points where the use of site-specific weed management can be based on economic reasons and to highlight those cases where more questions should be taken into consideration in the farming strategy.

Formerly it was created a stochastic simulation model (Monte Carlo model) that operates the relations between inputs-outputs and income, calculate the so-called viable criteria of break even point (threshold). Based on the main soil parameters, the weed coverage (species, density by management zones), damage-threshold principle was used to determine different farming strategies. The economic justification and risk of three farming strategies could be distinguished – 1. input (cost) minimalizing; 2. precision farming; 3. whole-surface damage minimalizing strategy – depending on nutrition level (based on soil features), weed coverage and selling price of yield (market conditions). Gross margin, economic efficiency depends on the intensity of production (level of nutriments of the soil, on the reaction of the species at a certain nutrition level, on weed coverage, competence between crop and weed, on the surplus costs of technology /or on the cost savings in different crops and of course on the selling price.

Precision weed management is a resilience farming strategy under Hungarian conditions, too. Should be supported the higher spread in practice (one tool of greening CAP component).

Keywords: chemical use, viability, modeling; risk reduction

JEL classification: Q0; C60; D220

Introduction

Due to radical innovation in agriculture, in technology more and more decisions should be made by the farmers if they want to operate in sustainable way. One direction is to apply tools of precision agriculture (PA). More we know about the advantages (both ecologic and economic advantages) of the technology not so common in the practice. Several former researches carried out that less use of artificial chemicals (material savings), more precise treatments (less environment burden) go to the technology, more knowledge (farming, informatics, economics), investment (capital, new machinery) and attention (managerial skills) are required. (Stull et al., 2004; Reichardt – Jürgens, 2009; Lencsés, 2013; EIP-AGRI, 2015; Tóth, 2015, Takácsné et al., 2018) A paradigm change of farming is needed. Also, it was highlighted that during the last 25-30 years its diffusion progresses is at a slow rate, less tools are implemented in the practice that we have from the point of view of innovation (machinery industry, chemistry, etc.)

The aim of this paper is to highlight the role of 'economic thinking'. The paper focuses on precision weed management. Higher is the variability of soil parameters, weed coverage of a farm, higher viability of PA. If the uncertainty of price changes (i.e. market changes) is high, the role of attitudes to environmental issues of farmers (decision maker) will increase in the usage of more PA tools.

Materials and methods

As a result of our former researches we created a stochastic simulation model (Monte Carlo model). (Takács-György – Takács, 2011; Takácsné, 2011) The model operates the relations between inputs-outputs and income, based on classical production functions of wheat, maize and sunflower. The production functions, cost functions and income functions are calculating by management zones. The implemented parameters effecting on yield are: intensification of production, the main soil parameters (i.e. soil humus content, K A), the weed coverage (species, density by management zones). We made the calculations on three differentiated nutrition and weed coverage levels (low, middle and high) using three selling prices on maize (corn), examining the economic viability and applicability of precision plant production (precision technology, including the capital return requirements).

The damage-threshold principle was used to determine different farming strategies. Based on the input-output relations three intervals can be determined based on incomes:

I: Basic treatment: „input minimizing strategy"

Threshold:

II: Precision farming $y^a(x) < y^p(x) \geq y^t(x)$

III: whole-surface damage minimalizing strategy (spreading the herbicide on the whole plot, without any differentiation)

The model calculates with random number generation the different combinations, examines the expected distributions (occurrences) for the damage threshold, giving-up threshold (the economically justified applicability range of precision farming) and the effect on them depending on different uncertain factors (i.e. changes in prices, weed density etc.) Results can be shown in a Decartes coordinate system, depending on the heterogeneity. (Figure 1)

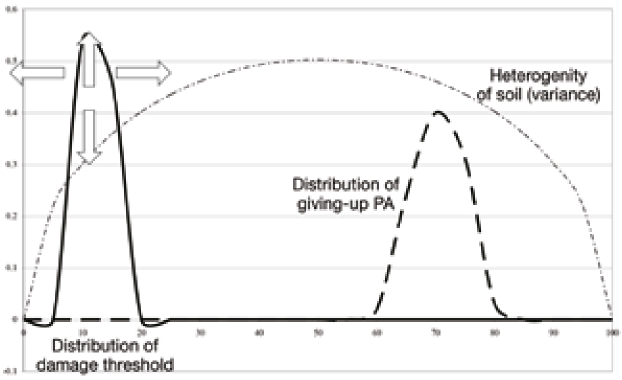

Figure 1. *Interval of justifiable use of PA*

As a result of our former researches we determined the optimal production structure after turning to precision plant production, the viable farm size that is necessary to cover the cost surplus connected to turning to new technology, while ensuring the return of capital investments, too. [Takács-György – Takács, 2009]

Results

Justification (economic viability) of precision farming depends on the available production value (intensity, yield, yield price), the ecological and soil quality and potential, its heterogeneity and on the nutrition level as well as on weed coverage and its heterogeneity.

More intensive production (higher nutrition, plant protection) serves as good reasons to turn to PA, the viable interval is wider reducing the economic risk (return) of the technology. If the price is expected to rise also the potential interval to be justified of using PA is wider. If weed coverage is stronger (more species, higher density, difference between the coverage at management zones) – that is unfavourable scenario for farmers – takes the same effect by decreasing the economic risk of precision farming, so PA is economically worth to turn. With the help of the results of the simulation model a risk-matrix can be set up that shows the risk of return of turning to precision plant production. (Table 1) In case of low weed coverage weed management is not required as long as not reaching the damage threshold – no treatment

is needed. If weed coverage is high and the numbers of cells, where the treatment is negligible, are low, the whole-surface treatment is proposed. Of course, in these cases turn to PA could happen not only based on economic considerations however substantial material savings in pesticides cannot be expected. An any other scenarios turning to PA (especially precision plant protection) will return economically, not even taking the role of precision farming in reducing environmental burden into consideration.

Table 1. *Economic risk of turning to precision plant production depending on soil features and weed coverage.*

Heterogeneity of weed coverage	Heterogeneity of soil parameters		
	Low	Middle	High
Low	+++	++	+
Middle	++	++	+
High	++	+	+

Legend:
+++ high risk without return
++ medium risk, uncertain return
+ low risk, probable return
Source: own calculations; Takács-György – Takács, 2009

Conclusions

The question that whom (which farm type) PA is economically justified for is not so easy to answer. Beyond the parameters built into the model itself (soil and weed parameters, species, coverage, on the reaction of the species at a certain nutrition level (input – output relations), on the competence between crop and weed, on the surplus costs of technology /or on the cost savings in different crops yield prices, level of nutrition and plant protection) should be highlighted the circumstances of the farm, production structure, farm size (concerning the questions of technology, machines, informatics), available services, skills and knowledge of management, their attitudes to environmental issues. Higher is heterogeneity of land and the number of cells where the treatment is not necessary could be significant thus the value of herbicide savings could be high. In those cases, where the soil is more homogenous higher is the number of management zones where it is not necessary to use herbicides the total, undifferentiated treatment is more profitable.

The decision on farming strategy will be made by the farmer (manager): To apply the different tools of PA (including fertilize and pesticide use) or not to use them. Of course, precision technology could also be used in all cases – taking into consideration of other advantages of precision farming that are not measurable today (e.g. external effects), its role in decreasing environmental burden –, but it must be admitted that it will make effect income (surplus) on farm level. Using PA is a real, resilience farming strategy that is suitable and profitable technology at certain farming size and intensity of crop production. Its technical, technological background is given, its spread to come into wide general use is expected only if the complex precision plant production is competitive economically for the producers or get some subsidy in the first years of introduction.

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