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COMPARISON ANALYSIS OF DIFFERENT DEGREES OF IMPLEMENTATION OF PRECISION FARMING TECHNOLOGY IN HUNGARY AND DENMARK

ANALIZA KOMPARATYWNA STOPNI WDROŻENIA TECHNOLOGII ROLNICTWA PRECYZYJNEGO NA WĘGRZECH I W DANII

Key words: sustainable agriculture, simulation, investment analysis, technology assessment
Słowa kluczowe: rolnictwo zrównoważone, symulacje, analiza inwestycji, ocena technologii

Abstract. The comparison analysis in this paper based on the data of national agricultural research institutes. The aim of this paper to defines the best investment of crop production technology for the Danish and the Hungarian farmers. The best investment strategy if the farmers use some precision farming elements with a combination of conventional methods according to the model calculation which examined the investment on 300 ha.

Introduction

The agriculture has play very important role in the life for thousands ages. The agricultural production has gone through big technological changes and became more and more efficiently. The first big change was when the steam-engine adopted in the agriculture after the industrial revolution. It makes the production easier and faster. The "modern" society also has these requirements but they have some new expectations from agriculture.

The primary function of the agriculture is still producing food. But over that the modern and globalized agriculture should handle new activities and requirements. For example: shape the landscape, provide environmental benefits, sustainable natural resource management, preservation of biodiversity, socio-economic viability. This is the reason why we called the modern agriculture a multifunctional agriculture. According to the OECD the multifunctional agriculture can produce numerous non-commodity outputs in addition to food [OECD 2000].

There are more and more tasks of the multifunctional agriculture from the first definition of that (it was 10 or 15 years ago). Nowadays the most important elements of the multifunctional agriculture are the following [DeVries 2000]: (1) produce raw material for food sector (produce higher yield with a lower cost), (2) viable rural communities (lot of country support small family farms to keep them in rural, because for them is important to preserve the local cultural heritages and improve the local economies), (3) environmental benefits (keep the biological diversity, improvements of water quality, increased soil health, better air quality) for example use fewer amounts of fertilizer and herbicides on the field; (4) food security, (5) landscape values (the beautiful rural landscape is an important point of the rural tourism for small farms particularly), (6) food quality and safety (importance of specific production methods to ultimate quality and safety of food), (7) animal welfare (serious regulation for treatment of livestock).

The main tasks of the modern agriculture are the efficient utilization of the resources, integrating the biological processes and regulating mechanisms of the production where it is possible and through this, confirm the cost-effectiveness of the agricultural manipulation, preserve agricultural human resources and retain living-standard of provincial society. Agriculture needs to face the challenge that it should produce the food for greater population on smaller field all over the world. The site-specific (precision farming) technology that is optimizing inputs (fertilizer, herbicide, pesticide, etc.) on parcel-level might be a solution for this problem. Thanks to the site-specific optimizing this technology increases the yield and decreases the environmental damages [Batte 1999, Kis, Takácsné 2006].

In the plant production process the most dangerous environmental impacts is the accumulation of chemicals (fertilizer, pesticides, herbicides, fungicides, etc.) in the soil and water. It does not mean that we should forget every chemical and use the ecological production. The important thing is to find the amount of the chemicals which is really needed on different part of the field. If it is possible the sustainable agriculture is not a future it become a present. The precision farming technology could be the instrument of this. Precision farming technology provides data and information to assist farmers when making site-specific management decisions [Arnholt et al. 2001].

In 2001 Arnholt and his co-writer examined the motivation of adoption precision farming system component in Ohio. There results based on survey questionnaire which 82 farmers who use precision farming technology send back. According to the result of this survey the most important motivation factor for using precision farming technology was to increase profits. Otherwise the most important benefits of the adoption was the more precise information about soil (PH, nutrition) and better understanding of yield variability [Arnholt et al. 2001].

The 10 most important motivation factors of adoption precision farming technology are the following: (1) increase profits by making better management decisions, (2) better understand filed variability, (3) stay on top of current technology available, (4) keep clearer, more accurate records, (5) decrease risk, (6) conduct on-farm experiments, (7) challenge to try something new, (8) comply with environmental laws/regulation, (9) price was right for the tools, (10) fun and enjoy learning to use the technology [Arnholt et al. 2001]. Really important question is how is the difference between the extra cost and the material cost saving. Very important economical question that how many years is the time of return and how many hectares is the breakeven point on different farm size and with different sowing structure in Denmark and in Hungary.

This paper tries to define the best degrees of implementation for Hungarian and Danish farmers calculate with the variable agro ecological possibility, different farm structure. Farmers find useful the precision farming technology because they think that it able to increase their income. Although they know that this technology application comes together with various very high costs. The majority of the farmers find that on their farm the benefits of the precision farming technology and the cost of it are equal or the benefits are little bit higher than costs. Only 5% of farmers think that the cost of the technology exceeds benefit [Arnholt et al. 2001]. The highest cost of precision farming technology by survey of Arnholt and his co-worker are the (1) service charges for variable rate application, (2) soil sampling and testing, (3) manager time required, and (4) consulting fees.

It is hard to say something about the adaptation or implementation level of precision farming technology because the statistical data about agriculture not include information about production technology (except of ecological area sometimes). The reason of this that is hard to say which farm is site-specific farm, because maybe it use only 1 or 2 elements of precision farming systems and combine that whit conventional elements. So they are conventional and precision farm in the same time.

Precision farming system contains several elements for example: soil sampling, variable rate application of fertilizer/lime/herbicides, site specific seeding, harvesting with GPS etc. From these elements the most frequently used was the grid soil sampling and the variable rate application (adopted in more than 80% of the farmers). But for example nobody used variable rate seeding. However, the results showed that farmers who adopted one or more elements of precision farming technology like to use more and more components in the future [Arnholt 2001].

Summarized the benefits of precision farming technology the highest rated is the precise knowledge of soil variety. The reduction of fertilizer is only on 5th place in the rank otherwise the decrease of herbicide is only on the 17th place from the 18 benefits. The environmental aspects take place in the middle (9th place) [Arnholt et al. 2001].

The PFT is used to be an internationally well researched topic. The center of the research of Weiss, Lowenberg-DeBoer and Boehlje is the microeconomic questions of PFT especially the classic production economic analysis. Thanks to this technology smaller and smaller farm size could realize profit. Kalmár et al. argued in a study (in 2004) that this technology is viable on the farm-size that includes more than 1,000 ha. Kovács and Székely claimed in 2006 that 250 ha are enough to viability. According to the latest researches this number could be 206 ha depending on the sowing structure [Kalmár et al. 2004, Kovács-Székely 2006, Takács-György 2007]. Knight and his co-author calculate in 2009 that the potential net benefit per hectare is Ł6 for farms of 300ha and Ł19 for 750 ha [Knight et al, 2009].

Material and methods

The aim of this paper to defines the best investment of crop production technology for the Danish and the Hungarian farmers. The crop production system contain six different elements (soil sampling, fertilizing, sowing, weed management, harvesting). Both elements are available with precision or conventional technology or in service. There are 864 combinations of these elements. This paper calculates both combinations of crop production elements to make the classical investment analysis and find the best combination for 300 ha farm.

In first step is to define an optimal sowing structure for a 300 ha farm which provides the highest income based on the cost/benefit data of Research Institute of Agricultural Economics[1] (these date show the average of the country). In Hungary examined four crops (which one by one occupied more than 5% of arable land) namely these are winter wheat, maize, industrial sunflower and rape. In Denmark examined only three crops (which one by one occupied more than 5% of arable land). The examined period is 10 year long. Provisions and bounds for the simulation model are:

– stipulations of crop rotation (temporal diversification) and intercropping (spatial diversification): winter wheat, spring barley and maize cannot be sawed in the same field for 2 years; this number is 6 years for sunflower and 4 years for rape,
– weather conditions: during the examination the model supposed that in 70% of the cases there were non-draught period and in the rest 30% there were draught period in Hungary, in Denmark draught period is not calculated,
– input prices (seeds, crop protection chemicals, fertilizer) were changed according to the weather conditions.

The gross margin calculation shows the difference between the sales and the production costs. The decision criterion during optimizing the sowing structure is to maximize the gross margin.

The following changes were made on these figures: the costs of the seeds (-4%), the artificial fertilizer (-15%) and the crop protection chemicals (-10%) were decreased – the latter one is true only for those corps that has wide row spacing (e.g. sunflower and maize). Besides, the expenditures connected with the machinery were raised by 20%.

Average costs and values of production data were determined separately for non-draught and draught periods and for each corps according to the data of the period 2000-2008. The simulation model uses these figures considering the standard deviations namely the value of randomized data could be somewhere between the maximum and minimum marginal values.

Constrains of the simulation model are typed into the solver (model of MS Excel). It is very important that the result must be set to zero before running the solver – it means that the former result must be deleted before re-running the algorithm. The simulation model was executed 50 times as the way it was previously mentioned. We found that this is enough because the results were very similar to each other.

Table 1. Few combination of production elements with different methods

		Number of variation														
Methods		1.			2.			3.			4.			5.		
		P	C	S	P	C	S	P	C	S	P	C	S	P	C	S
elements	1			x			x	x					x		x	
	2		x		x				x			x			x	
	3		x			x				x	x			x		
	4	x			x			x				x			x	
	5			x	x				x		x					x

P – precision farming technology, C – conventional technology, S – service
1– soil sampling; 2 – fertilizing; 3 – sowing; 4 – weed management; 5 – harvesting
Source: own study.

After the optimal sowing structures were determined the next step is to define all possible combination of precision farming, conventional farming and service use (service means precision farming service) elements. The number of different combination is 864. Table 1. shows few possible variation of technology elements. For example it is possible that use precision weed management, conventional fertilizing and sowing and make soil sampling and harvesting in service (Tab. 1).

If the farmer use precision sowing (in own or in service) should calculate with 4% saving in seed cost. If farmer

[1] They are namely Agárgazdasági Kutató Intézet in Hungary and Dansk Ladbrugsrĺdgvigning, Landbrugsforlaget in Denmark

Table 2. Gross margin, net present value and return point in few examined variation

Number of variation	Crop production elements				Investment cost	Annual outcomes	Annual production value	Annual gross margin	Total gross margin	NPV	Return point [year]	Ranke
	sowing	fertilizing	weed management	harvesting	EUR/300 ha							
HUNGARY												
100	S	P	P	S	134 580	83 666	177 673	94 007	940 068	402 774	1,4	1st
112	S	P	C	S	130 650	83 273	177 673	94 400	943 998	408 542	1,4	2nd
148	S	C	P	S	134 550	83 663	177 673	94 010	940 098	402 818	1,4	3rd
160	S	C	C	S	130 620	83 270	177 673	94 403	944 028	408 586	1,4	4th
368	P	P	S	P	146 580	83 666	177 673	94 007	940 068	391 865	1,6	5th
400	P	P	C	S	142 650	83 273	177 673	94 400	943 998	397 633	1,5	6th
436	P	C	P	S	146 550	83 663	177 673	94 010	940 098	391 909	1,6	7th
676	P	P	P	S	146 580	83 273	177 673	94 007	940 068	391 865	1,6	8th
DENMARK												
110	P	P	C	S	126 410	286 122	344 290	58 169	581 685	210 009	2,2	1st
114	C	P	C	S	126 320	286 113	344 290	58 178	581 775	210 142	2,2	2nd
158	P	C	C	S	126 320	286 113	344 290	58 178	581 775	210 142	2,2	3rd
162	C	C	C	S	126 230	286 104	344 290	58 187	581 865	210 274	2,2	4th
398	P	P	C	S	126 410	286 122	344 290	58 169	581 685	210 009	2,2	5th
402	C	P	C	S	126 320	286 113	344 290	58 178	581 775	210 142	2,2	6th
446	P	C	C	S	126 320	286 113	344 290	58 178	581 775	210 142	2,2	7th
686	P	P	C	S	126 410	286 122	344 290	58 169	581 685	210 009	2,2	8th

P – precision farming technology by own; C – conventional technology by own; S – service with precision farming technology
Source: own study.

use precision fertilizing it comes with 15% decrease of fertilizer cost. In case of weed management the possible herbicide saving is 10%. The machinery cost grow with 5% with own precision farming elements. Thanks to the site-specific production the yield increase with 10%.

After sowing structure, producing methods, investment cost and annual variable cost determined, we are able to make classical investment analysis. To make simpler the model we just calculate with net present value (NPV)[2] and return point. And finally the best 8th production methods will be showed. The NPV held us to determine which investment is good for implementing if the interest rate is 10%. The best has a highest income in the 10 year period and has a shortest return point.

Results and discussion

Based on the data of Hungarian Research Institute of Agricultural Economics and calculate with the stipulations of crop rotation and intercropping, the weather conditions and the estimated input prices the best sowing structure (give the highest gross margin) on 300 ha is the following: winter wheat 144 ha, maize 60 ha, industrial sunflower 51 ha and rape 45 ha.

Based on the data of Danish LandbrugsInfo and calculate with the stipulations of crop rotation and intercropping, the weather conditions and the estimated input prices the best sowing structure (give the highest gross margin) on 300 ha is the following: winter wheat 147 ha, spring barley 68 ha, rape 85 ha.

The model calculation shows

[2] Net present value (NPV): the present value of an investment's future net cash flows minus the initial investment. If positive, the investment should be made (unless an even better investment exists), otherwise it should not.

that under the Hungarian conditions both 864 combination have positive NPV and the return point is less than 3,5 year (the average is 2,5 year). Otherwise under the Danish conditions in some cases the return point is around 8 year (but the average 4 year) and in 10 cases the NPV is negative.

Examining the maximum of the gross margin in 10 years the best is when the sowing and harvesting is made in service (precision farming), and fertilizing and weed management in precision way with own equipments in Hungary according to the model. The best in Denmark if the sowing and the fertilizing are in precision farming technology make conventional weed management and harvesting in service with a site specific way (Tab. 2).

Conclusion

When farmers start to think about what should they do on 300 the first steps is to find out which sowing structure is the best for the weather and market conditions and his own knowledge. Our simulation suggest that in Hungary the average optimal sowing structure is: winter wheat 144 ha, maize – 60 ha, industrial sunflower – 51 ha and rape 45 ha and in Denmark it is the following winter wheat 147 ha, spring barley 68 ha and rape 85 ha.

Because of Denmark situated in a colder but more vet climate than Hungry there is a difference between the sowing structures. Although in both country crops, mostly the winter wheat, are the most famous or popular plant in the agriculture.

The costs of seeds and herbicide are really similar in Denmark and in Hungary. But in Denmark the price of the fertilizer is much higher than in Hungary. The other difference is in the yield. In Denmark the yield is very balances year by year, because the weather conditions are similar year by year. In Hungary the farmers should calculate with danger of drought.

The farmers can choose a lot of different plant production technology for example ecological, conventional or precision farming methods. In this paper 864 different combination of precision farming (in own and in service), conventional farming are determined and examined it from classical investment analysis aspect (NPV and return point). We found that in lot of cases investment costs come back around 2 years.

The investment cost of the total precision farming technology is 250 000 euro on 300 ha. This comes back around 3 years in Hungary. In Denmark this cost is 180 000 euro, which comes back in around 4 years.

Besides, ecological aspect should not been forgotten either because precision farming technology is more environmental friendly than the conventional technology of crop production which means a kind of improvement as for sustainability of agribusiness.

Furthermore, the aspect of changes in inputs is also important. Apart from the fact that precision farming technology requires investment in equipments that needs to be maintained, it has a lot of advantages as well for instance more stabile annual yields and reduction of operating expenses (fertilizer, chemicals, pesticides, herbicides).

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Streszczenie

Celem artykułu była ocena opłacalności technologii produkcji roslinnej w Danii i na Węgrzech oraz wyodrębnienie najlepsych gospodarstwj z punktu widzenia strategii inwestycyjnej. Do analizy porównawczej wykorzystano dane z krajowych instytutów badawczych. Stwierdzono, że najlepsza strategia inwestycyjna w modelu zoptymalizowanym dla 300 ha zakłada wykorzystanie elementów rolnictwa precyzyjnego w połączeniu z metodami konwencjonalnymi.

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