DE GRUYTER
OPEN

DOI: 10.1515/agriceng-2016-0023

ISNN 2083-1587; e-ISNN 2449-5999
2016,Vol. 20,No.2, pp.23-30
Agricultural Engineering
www.wir.ptir.org

THE USE OF PRECISE AGRICULTURE TECHNOLOGY IN A FARM IN PODLASIE REGION

Andrzej Borusiewicz[a*], Krzysztof Kapela[b], Paulina Drożyner[c]

[a] Department of Agronomy, The Academy of Agrobusiness in Łomza
[b] Department of Agronomy, Siedlce University of Life Sciences and Humanities
[c] Department of Safety Foundations, University of Warmia and Mazury in Olsztyn
[*] *Corresponding author: e-mail: andrzej.borusiewicz@wsa.edu.pl*

ARTICLE INFO

Article history:
Received: November 2015
Received in the revised form:
January 2016
Accepted: February 2016

Key words:
precise agriculture,
production,
farm,
Podlasie region

ABSTRACT

The article presents advantages resulting from implementation of the precise agriculture technology in a farm. The objective of the paper was to analyse devices used in precise agriculture on the example of the selected agricultural farm located in Podlaskie Voivodeship. Documentation of the farm and data included in the questionnaire of the survey carried out with the farm owner were the source of indispensable information. For determination of the costs of return of investments planned in the farm, the method of data analysis and TeeJeet calculation were used. Implementation of the precise agriculture technology in the investigated farm caused reduction of the costs related to running a farm. The introduced changes allowed saving approximately PLN 14 thousand annually on crop protection treatments and approximately PLN 19 thousand annually on the precise sowing of mineral fertilizers. Costs related to the purchase of devices which allow generation of such savings return after 3-4 years.

Introduction

Functioning of the modern society and aspects related thereto, such as: technological progress, globalization and climatic changes enforce changes in the functioning of enterprises. These factors have a great impact on shaping people's awareness and as a consequence on the new challenges which business entities face. Agriculture is the most developing sector of the Polish economy where intensive changes take place. The most important aspect is the change in farmers' awareness. They purchase modern machines and devices in order to improve the work conditions as well as increase the income from a farm (Korzeniowski, 2013).

In order to increase production competitiveness at the simultaneous meeting of requirements for producers and consumers, the precise agriculture technology is used. It mainly consists in collection of data on the soil resourcefulness, fertilization, protection and spatial variability of crops within a particular field (Narkiewicz, 2007). Preparation and proper interpretation of yield map are the most important elements at the implementation of the precise agriculture technology in a particular farm. Based on the prepared map, a farmer

may use fertilization and crop protection treatments in relation to the yield potential of a given field area (Sawa and Parafiniuk, 2000; Minta, 2008; Doruchowski, 2008; Gozdowski et al. 2007).

An underlying objective of implementation of the satellite farming is improvement of the efficiency of agricultural production. This improvement should consist in reduction of input such as lower consumption of fuel, fertilizers, crop protection substances at the simultaneous increase of work efficiency and production size and at the same time in the improvement of the quality of manufactured goods and maintaining the principles of sustainable development (Hołownicki, 2008). Efficiency of using precise agriculture rules depends on the following factors: the rate of the increase of exploitation costs of machines caused by the use of additional equipment, the change of quantity and quality of the product, the reduction of materials consumption and benefits for the natural environment (Biskupski, 2003).

Implementation of the precise agriculture technology to a given farm is related to the demand for the registering devices including technologies of variable dosing. Equipping machines in such devices is related to the increase of their prices which consequently causes the increase of their exploitation costs (Przybył, 2007; Korzeniowski, 2013).

Economic efficiency of precise agriculture is not only affected by the price of additional equipment related to the use of such system but also by the area of fields, crops and annual use of machines. Costs of machines exploitation calculated into the production unit are reduced along with the increase of their crops. In small and average farms the use of simplified forms of precise agriculture which do not require purchasing of expensive registering and controlling devices, is purposeful (Biskupski, 2003).

Precise agriculture ensures a high level of food safety. Due to constant monitoring, great precision of treatments as well as optimization in time, meeting great requirements of consumers and agricultural products processors is not an issue. It mainly concerns undesirable trace substances, synthetic fertilizers: nitrate, chloride, pesticides as well as pathogens and pests: viruses and fungal diseases. Great optimization and efficiency of carrying out agro-technical treatments (crop protection) allow avoiding double dosing of any chemical parameters and their area shortage. It allows achieving a sustainable economic and quality effect with maintaining the requirements of environment protection (Wasilewski, 2004).

Implementation of precise agriculture rules to specific farms is preconditioned by technical, social and educational and economic aspects. Technical preconditions include: the possibility of using modern technology, automation and informatization (Harasim, 2006).

Objective, scope and methodology of research

The objective of the paper was to analyse the usage of devices in the satellite farming technology, on the example of the selected farm located in Zburzyca Mała, Szudziałowo municipality, in Sokólski province (Podlaskie Voivodeship). A 200 ha farm is a family, multi-generational farm, which specializes in grain crops cultivation and cattle breeding. Cultivation fields have a varied size, most often they are approx. 10 ha with prevailing soils of III and IV class. Every year fields are sown with the following plants: 40% wheat, 30% triticale, 20% barley, 10% mixtures of wheat with leguminous plants.

In order to carry out a full analysis of a farm, a survey was carried out with the farm owner and information included in the farm documentation was used. For determination of savings possible to be obtained at the implemented system of precise agriculture and the costs of the planned investment return in the investigated farm, the data analysis method was applied. Moreover, TeeJet calculator was used. The calculator of savings of automatic control of sections allow determination of savings which we will obtain by precise agro-technical treatments such as the use of crop protection substances of fertilization.

Research results

The biggest acreage in the farm is taken by winter wheat crop Astoria cultivar. Triticale and barley are cultivated on the smallest acreage (Table 1). These grains are designed for fodder for cattle, and surpluses are sold. Mixtures with leguminous plants designated for meat cattle fodder are also cultivated. Some part of the obtained direct subsidies is designated for the purchase of straw, grass and other fodder for meat cattle. Moreover, companion crops, after-crop and inter-crops are used in order to ensure proper rotation.

Table 1.
The area of cultivation of particular plants in the investigated farms in 2010-2014

Category	2010	2011	2012	2013	2014
	(ha)				
Wheat	90	80	90	100	100
Triticale	40	40	40	26	26
Barley	40	40	40	34	34
Mixtures	30	40	30	40	40

In farm buildings, young meat cattle is bred, most often purchased from neighbouring farmers and bred to the weight of 300-400 kg and pigs. Livestock of animals in 2010-2014 in the investigated farm was presented in table 2.

Table 2.
Livestock in the investigated farm in 2010-2014

Category	2010	2011	2012	2013	2014
	(items)				
Young beef cattle	28	30	35	38	40
Pigs	10	8	12	10	10

Machinery park, livestock buildings and a farm part are clearly separated from the house. Various machines and agricultural devices which facilitate farmers' work are used. A farmer owns: 4 farm tractors with varied power, 3 combines, 4 trailers, fertilizer spread-

ers, sprayers, grain sowers, aggregates for field cultivation and others. Thanks to the use of EU funds, manure pad, liquid manure reservoirs were constructed and old livestock buildings were modernized. The owner carries out planned waste and sewage management. Additionally, the farm is equipped with a fodder mixture and the closed container for grains. Buildings in the farm, although they were built few or even few dozen years ago are in a good condition.

Strengths of a farm include: higher education of a farm owner, variability of animal production, having an appropriate number of farm machines and devices, location of a farm near own fields and good quality of soils. A farm, which has a great area of field crops may on time, better and more efficiently use the owned machinery park. The farm relies on almost full self-reliance of plant production for the need of animal breeding, as a result of which plant crops produced in a farm are varied. Some part of produce is sold, and production surpluses are used as fodder for animals.

Weaknesses of the farm are as follows: no fixed recipients of products, high defragmentation of the agricultural acreage, varied work expenditures and a considerable participation of a farmer therein, no owned calves for breeding, no relevant amount of fodder for young cattle and low profitability of agricultural production.

Chances for a farm are as follows: possibility of obtaining EU funds for farm development, increase of the acreage, increase of cattle livestock and obtaining new outlets for products.

Research results and discussion

The precise agriculture technology was applied in the investigated farm for the first time in 2010. It was a device which served for collection of soil samples equipped with the GPS system. Based on the analysis of soil samples, maps of soil, pH and resourcefulness of soil in phosphorus, potassium and magnesium were developed. Resourcefulness maps were created with the use of AgroWIN programme. They are particularly used for manual determination of field areas with a varied pH and to determine calcium doses based thereon. The owner could have not used the owned resourcefulness maps to a wider extent because he did not have a fertilizer spreader, which would be able to sow a fertilizer dose which depends on the soil resourcefulness in a particular element. On account that conversion of owned spreaders is quite expensive, the farmer plans a shift to a full use of the variable dosing of fertilizers with replacing old spreader with new ones.

Since 2011, in order to improve precision of pre-sowing use of fertilizers, the farm owner bought and uses the GPS OUTBACK S assist system of a farm tractor for parallel drive. This system is mounted on tractors which cooperate with spreaders by Amazone company with the working width of 24 and 36 metres. Due to the use of this system the number of left spots and places where fertilizer could be applied in double quantity was reduced. Moreover, the system enables precise sowing of fertilizers in the evening hours, at night or in bad weather. The farmer also bought a crop measuring device in 2011. They were mounted on Class Lexion 560 combine harvesters, which additionally are equipped with GPS. Crop maps of grains are made with the use of AGRO-MAP program. Following the purchase of modern spreaders they will be used for precise determination of fertilizers doses. These maps allow identification of field areas where the crop decreased and its pre-

sumed reasons were identified (pathogens, faulty drainage system). Following the purchase of modern spreaders they will be used for precise determination of fertilizer doses. Furthermore, in 2014, in a farm, the AutoControl system, which enabled constant analysis and optimization of using tractors in a farm, was tested. In the tested period, a farm owner considered implementation of this system for the purpose of possible financial savings. The next scheduled investment concerns the purchase of Amazone ZA-ST fertilizer spreader equipped with GPS switch which allows automatic switching on the sowing width section.

Great funds have been invested in the recent years in order to increase the standard and work efficiency in the farm and the applied solutions are commonly used in modern farms. Additional investments are planned, advantageous for the economy of the farm: modernization of the machinery park which would assist the installed systems and help in a faster and more effective performance of tasks and increase the level of agricultural production specialization level related to further modernization of a farm on account of the business profile (Table 3).

Table 3.
Scheduled investments concerning the farm development with the time required for refund of the investment

Investment type	Cost of purchase of devices (PLN)	Time required for refund of incurred costs (years)
GPS OUTBACK S device	16000	3
LPS device		
Crop-Meter	8350	
GPD MAP 62s device	2000	
Spreader Amazone ZA-TS along with GPS MATRIX PRO.	70000	4
Investigation of soil with resourcefulness map	12650	
Together	109000	x

Precise agriculture treatments include the following when the above mentioned changes are calculated: carrying out a precise soil test, spraying with crop protection substances and spreading mineral fertilizers in order to improve plants resourcefulness in nutrients. Based on the analysis of data, savings were calculated which can be obtained at the use of modern spraying system in relation to the farm area, annual amount of carried out treatments at the predicted precision of spraying by 14% on the area of 200 ha at 5 crossings annually and the average cost of spraying on 1 ha in the amount of PLN 100. Due to the use of this technology, the amount spent on carrying out crop protection treatments will decrease by PLN 14 thousand per year.

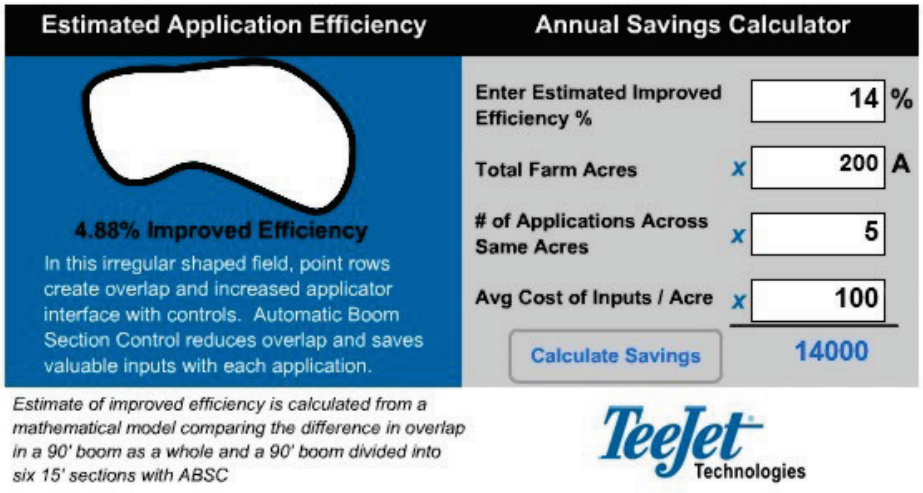

Figure 1. Example of TeeJet Technologies calculator screen

The situation with the use of a modern fertilizer spreader is similar. In a farm in 2014 the fertilization plan assumed application of mineral fertilizers on crops on 200 ha area with four fertilization treatments: pre-sowing fertilization, nitrogen top dressing in three doses. The analyses show that in the described farm, savings were at the level of 15% and that would be approximately PLN 19 thousand annually. The cost of purchase of precise agriculture devices will bring advantages in the fourth year of its use at implementation of precise use of crop protection substances and fertilization.

Development of precise agriculture in Poland and worldwide is limited by high costs of the technology. They are reduced along with popularity and mass production of machines and devices related thereto. New technologies of precise agriculture may be mainly introduced in multi-area farms.

Multi-area farms have great acreages as a result of which economic and quality effect is visible due to the production scale. The most outstanding savings in multi-area farms having at the minimum 300 ha of arable land results from implementation of precise fertilization treatment and using plant protection. The advantages related to the application of precise management are estimated as approximately 37 PLN·ha^{-1} (Borusiewicz and Kapela, 2014).

In order to limit high costs of purchase of systems and devices of precise farming, farmers may buy the equipment as a part of producers' groups or neighbour cooperation of farmers. Due to a low amount of small farms which have low crops, fragmentation of crop area, introduction of precise farming technology may be non-effective.

The use of precise farming methods stabilizes obtained crops, including efficiency at a relatively high level. Additionally, these methods based on the collected data, enable evaluation and forecast of the level of cropping. Due to the tendency of increasing food safety on each stage of the chain of processing and distribution of produce, which result in the food safety standards requirements HAACP, precise farming techniques may soon be-

come one of the desired elements of the production system. Jabłoński (2008) in his research stated that precise row fertilization allows decrease of the dose and reduces production costs without detriment to the quality of potato bulbs. At the nitrogen dose 60 kg $N \cdot ha^{-1}$ the crop of the same size was obtained at the dose of 130 kg $N \cdot ha^{-1}$applied traditionally by means of broadcasting.

Precise agriculture is a production system which is attractive for the sector of food processors and food suppliers. It allows obtaining the raw material which can be predicted with regard to the quality and quantity with the simultaneous possibility of tracing and control of technology of its production (control of resourcefulness, doses of fertilizers, pesticides, crops).

The main factor which limits the satellite farming development in Poland consists of the purchase costs and costs of introduction of innovative technologies to a farm. The second factor which influences introduction of precise farming systems is the size and fragmentation of farms. These technologies are most often introduced in multi-area and commodity farms, where economic and quality effect is noticeable. Also, a human factor is responsible for low degree of use of precise farming − implementation and correct use of potential of IT and technological potential ICT requires awareness and knowledge.

Conclusions

1. The precise agriculture system has a significant impact on the costs related to agricultural farm through agro-technical treatments which are carried out with higher precision in traditional farms.
2. Implementation of precise agriculture technology in the investigated farm will allow saving of approx. PLN 14 thousand annually on crop protection treatments and approximately PLN 19 thousand annually at precise sowing of mineral fertilizers.
3. Costs related to the purchase of devices which allow generation of such savings in the investigated farm will return after 3-4 years.

References

Biskupski, A. (2003). Efekty agrotechniczne, środowiskowe i ekonomiczne w uproszczonej uprawie roli. *Upowszechnianie zasad dobrej praktyki rolniczej*, IUNG, Puławy.

Borusiewicz, A., Kapela, K. (2014). Wdrożenie technik rolnictwa precyzyjnego na przykładzie wielkopowierzchniowego gospodarstwa rolnego. *Inżynieria Rolnicza, 2*(150), 31-37.

Doruchowski, G. (2008). Postęp i nowe koncepcje w rolnictwie precyzyjnym. *Inżynieria Rolnicza, 9*(107), 19-31.

Gozdowski, D., Samborski, S., Sioma, S. (2007). Rolnictwo precyzyjne. Warszawa. *Wydawnictwo SGGW*, ISBN 9788372448583.

Harasim, A. (2006). Przewodnik ekonomiczno-rolniczy w zarysie. *Wydawnictwo IUNG Puławy*, ISBN 83-89576-36-8.

Hołownicki, R. (2008). Przed agroinżynierią stoją nowe zadania. *Inżynieria Rolnicza, 4*(102), 13-24.

Jabłoński, K. (2008). Maszyny i urządzenia do precyzyjnego nawożenia ziemniaków i efekty produkcyjne. *Inżynieria Rolnicza, 1*(99), 119-126.

Korzeniowski, S. (2013*).* Rolnictwo energetyczne i precyzyjne: wybrane zagadnienia. *Wydawnictwo PWSZ w Suwałkach.* ISBN 978-83-934-3405-3.

Minta, S. (2008). Rolnictwo precyzyjne jako nowoczesny sposób podniesienia konkurencyjności gospodarstw rolniczych – aspekty ekonomiczne i środowiskowe [w:] *Roczniki Naukowe SERiA, t. 10, z. 3, 4*03-406.

Narkiewicz, J. (2007). GPS i inne satelitarne systemy nawigacyjne. *WKŁ,* Warszawa. ISBN 978-83-206-1642-2.

Przybył, J. (2007). Nowoczesna Technika [w:] Zboże wysokiej jakości, wyd. 3, *Agro Serwis, Warszawa.*

Sawa, J., Parafiniuk, S. (2000). Kierunki zmian w systemie produkcji rolniczej i poziomie mechanizacji w badanych gospodarstwach. *Inżynieria Rolnicza, 8*(19), 119-124.

Wasilewski, M. (2004). Wykorzystanie liniowego modelu optymalizacyjnego do programowania dochodu rolniczego i płynności finansowej gospodarstw indywidualnych. Koncepcje i narzędzia zarządzania informacją i wiedzą, red. Niedzielska, Perechuda. *Wydawnictwo WAE*, Wrocław. ISBN 83-7011-734-1.

Kalkulator oszczędności automatycznego sterowania sekcjami. Pozyskano z: http://www.teejet.com/polish/home/calculator/absc-savings-calculator.aspx.

ZASTOSOWANIE TECHNOLOGII ROLNICTWA PRECYZYJNEGO W GOSPODARSTWIE ROLNYM NA PODLASIU

Streszczenie. W pracy przedstawiono korzyści wynikające z wdrożenia technologii rolnictwa precyzyjnego w gospodarstwie rolnym. Celem pracy była analiza zastosowania urządzeń wykorzystywanych w rolnictwie precyzyjnym, na przykładzie wybranego gospodarstwa rolnego, położonego w województwie podlaskim. Źródłem niezbędnych informacji wykorzystanych podczas analizy była dokumentacja gospodarstwa oraz dane zawarte w kwestionariuszu wywiadu przeprowadzonego z właścicielem gospodarstwa. Do określenia kosztów zwrotu planowanych w gospodarstwie inwestycji wykorzystano metodę analizy danych dodatkowo wykorzystano kalkulator firmy TeeJeet. Wdrożenie technologii rolnictwa precyzyjnego w badanym gospodarstwie przyczyniło się do obniżenia kosztów związanych z prowadzeniem gospodarstwa. Wprowadzone zmiany pozwoliły zaoszczędzić około 14 tys. PLN rocznie na zabiegach ochrony roślin oraz około 19 tys. PLN rocznie na precyzyjnym wysiewie nawozów mineralnych. Koszty związane z zakupem urządzeń pozwalających na wygenerowanie takich oszczędności zwracają się po około 3-4 latach.

Słowa kluczowe: rolnictwo precyzyjne, produkcja, gospodarstwo rolne, Podlasie