FARM MACHINERY AND PROCESS MANAGEMENT IN SUSTAINABLE AGRICULTURE

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Edited by

Bruno Huyghebaert, Edmund Lorencowicz, Jacek Uziak

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INTRODUCTION

The International Scientific Symposium on « Farm Machinery and Process Management in sustainable Agriculture » aims at introducing all the on-going or concluded researches that enhance the sustainability of our agriculture. We hope that once again this Symposium will be the platform for an international synergy and cooperation between experts from different countries who are working on specific areas related to sustainable agriculture.

While sustainable agriculture covers a large variety of topics, the Symposium will focus on five main subjects, this year: Economy, Energy, Environment, Evaluation and Equipment. To make our agriculture sustainable will certainly be the main objective of R&D and equipment suppliers in the coming years. How to ensure the farmer an activity that is economically viable while respecting and preserving the environment? How to develop new equipment or technologies while decreasing energy consumption? How to evaluate the performances of new processes? These are questions among many that the Symposium will touch and give elements of answer.

We are pleased to remind you that this International Congress is the result of a long and fruitful cooperation between the Lublin University of Life Sciences and the Walloon Agricultural Research Centre. This year, for the first time, the Symposium is organized in Belgium.

We warmly thank all participants and the different institutions and companies that enabled us to prepare and organize this Symposium. We also express our deep gratitude to all members of the Reading Committee for their intensive collaboration.

The Organizing Committee

ECONOMY

STRATEGIC ANALYSIS OF FARM DEVELOPMENT IN POLAND BY 2030[1]

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Keywords: strategic situation of farms, farm competitiveness, sustainable development of agriculture

Abstract

The future of Polish agriculture has been a major topic in discussions among Polish but also foreign agricultural economists, particularly in recent years, especially since Poland's accession to the European Union.

The study was an attempt to identify model strategic situations to be faced by farms. It is assumed that within the next 25 years considerable changes will take place in Polish agriculture. Investigations were conducted in view of two issues considered priorities for the development of agriculture and rural areas in Poland, i.e. sustainable development and improved competitiveness of farms. Taking into consideration the developing macroeconomic situation and changes in production systems and technologies in agriculture four strategic situations were distinguished, referred to as stagnation, crisis, reorientation and development.

The conducted analysis showed that by the year 2030 the number of farms will be reduced to 700 - 750 thousand. Moreover, in view of the current and forecasted trends in European agriculture as well as changing consumer preferences it is expected that out of that number approx. 10% will apply ecological production methods, another 20% will belong to the category of the largest farms which will use modified large-scale production methods, while the last group, constituting the

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most numerous population (approx. 70%) will comprise farms using integrated production methods.

Introduction

It is justified to conduct discussions and search for answers to questions concerning the status of Polish agriculture in 25 years' time. The importance of agriculture may not be described solely using simple statistical indexes. Agriculture will not cease to be important, although its share in the GNP structure has decreased almost 5 times since 1990 and currently accounts for only 1 – 2%. A village without agriculture may no longer be a village – it becomes just another housing estate. Moreover, the predominant feature of agriculture, the necessary precondition of its survival and development stems from the fact that so far no substitute has been found for food and agriculture still remains the primary source of food for mankind. The future of Polish agriculture has been a major topic in discussions among Polish agricultural economists, particularly in recent years, especially since Poland's accession to the European Union (Józwiak, 2004, Anania, Azcarate et al., 2003, Runowski, 2004, Woś and Zegar, 2004, SERiA, 2005, Józwiak, 2005, Woś, 2005, Wilkin, 2005, Wójcicki, 2006).

The aim of the study was to determine model types of strategic situations of farms by the year 2030. Since it was assumed that production systems and technologies are those areas in which the biggest changes are going to take place in Polish agriculture, considerations focused on two strategic problems, considered to be priorities for Polish agriculture, i.e. sustainable development and improved competitiveness of farms.

Methods

The following macroeconomic factors were included in the assumptions adopted in the analysis:
   - increased economic effectiveness (thanks to restructuring and modernization) of farms at the simultaneous increase of labour costs in Poland,
   - a multifunctional model of European agriculture (the development of non-productive functions of agriculture),

- strong pressure put by consumers and increasing requirements posed by the market concerning the quality and safety of agricultural products and food,
- development of commercial agriculture (both conventional and ecological) will be based on knowledge (substitution of labour with capital, transferring modern production technologies),
- generational change in agriculture,
- a transformation of the agrarian structure of farms, at the simultaneous reduction of the agriculturally utilized area (AUA).

Research results

When analyzing different types of strategic situations faced by Polish farms we may distinguish 4 basic variants, which are included in the matrix presented below (Fig. 1).

Figure 1: Model types of strategic situations of farms (source: the authors' study)

Most probably strategic situation A is faced by farms with an area from 5 to 20 ha AUA. Their competitive position will be weak and the production profile will have been stabile and unchanged for years. This group is likely to comprise farms belonging to older farmers and younger farmers who have not sufficiently broadened their knowledge to include market trends, marketing aspects and

technological innovations. This group may also include small producers' farms, which previously used financial support and were included in the group of farms with economic vitality of over 4 ESU, but which ceased to implement further restructuring actions and have problems with defining their further reorientation. These farms are as if in a state of limbo – they are too strong economically to go bankrupt and at the same time their economic potential will be too weak for them to develop further and effectively compete on the home and EU markets.

Strategic situation B will most probably be found in the smallest farms, up to 5 ha, and those larger ones which for various reasons have not adapted to meet EU standards concerning e.g. veterinary requirements, facilities to store farm manure, regulations concerning animal welfare, etc. In the future control of the above regulations may be expected to tighten and be combined (the cross-compliance principle) with taking away subsidies or imposing specific fines. The fact that these farms have not responded to the changing economic conditions, have not had a vision of development resulting mainly from the fact that for many previous years they operated in strategic situation A and went with the flow, will be a bad omen for the future of these farms. Farms from field B may be saved by an immediate reaction implementing radical changes in the organizational structure, technological standards, product quality, the scale of production, etc. However, this would require essential changes in management of the farm and – what is probably more difficult to attain – considerable capital.

Strategic situation C includes a specific somersault – drawing timely and appropriate conclusions from the approaching danger and using the crisis as a chance, a turning point in development. These farms need to have a strong motivation to operate further, as well as a potential (human resources, engineering and technological, as well as capital) sufficient to undergo a breakthrough strategic reorientation. Most probably this reorientation will require from those entities a certain redefinition of their operation, changes in the organizational structure, cost reduction and reinforcement of financial control, changes in production methods, distribution, etc. This group will include e.g. strong conventional farms, which will turn to ecological or integrated agriculture, or economically weaker farms, which will take advantage of their chance and find additional sources of income or financial support – within the framework of agri-environmental programs, groups of

agricultural producers, measures facilitating an easy start in business to young farmers or to diversify agricultural activity and activities related to agriculture.

Field D of the matrix will comprise well-functioning farms, yielding good economic results, with good financial standing, which previously used to the maximum access to financial support in terms of instruments of EU agricultural policy. They are most likely to be large market-oriented farms using precision farming methods, as well as the most dynamic family farms applying integrated and ecological methods of production. The dominant feature of these farms will be the strategy of entrepreneurship. Those farms will be characterized by an open-minded attitude, innovations and prompt adaptation to the needs to diverse interested parties.

Taking into consideration forecasted changes in farm subsidies and probable changes in the tax system and farmers' insurance, a likely scenario is for the total number of farms in 2030 to drop by 50% and amount to 700 thousand. In view of trends observed in European agriculture and the so-called consumer preferences it may be expected that out of the total number of farms in 25 years' time 10% of the farms will use ecological production methods. Approximately 20% of the farms will comprise the group of the largest commercial farms, which – although in a milder, more ecologically friendly form – will still apply the industrial model of development to agriculture. The others, i.e. approx 70% farms, will use integrated production methods.

Conclusions

Summing up it needs to be stated that the forecasted development of the macroeconomic situation may in the future strongly complicate the strategic situation of farms in Poland.

Farms will respond to the occurring changes in various ways. The following characteristics and assessment of the economic standing of farms may be presented here:

   1/ For the biggest farms a considerable problem will be connected with difficulties with hired labour. Market-oriented farms will compensate for these problems with a potential for growth in terms of the scale of production and

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resulting profits. A reduction of financial support to production within the reformed CAP and the prospective appearance of cross-compliance and modulation mechanisms will require from these farms changes implemented in the organization of production, outlays for labour, in material assets of production factors and applied technologies.

2/ The group of large family farms (20 - 300 ha AUA) will also prove economically efficient. In the countries of the so-called old European Union, e.g. Germany, these farms are exceptional in terms of their size (40 - 100 ESU). The number of these farms will not be growing, but undoubtedly they will increase in area by incorporating smaller, economically weaker farms.

3/ In the danger zone there will be farms with an area ranging from 5 to 20 ha AUA (the income bracket of 8 to 40 ESU). Although these farms have a commercial type of production, they are too small and characterized by insufficient economic vitality to meet market competition. The number of these farms will gradually decrease.

4/ The biggest changes will take place in the group of the smallest farms, with only a slight market role and an area up to 5 ha (up to 8 ESU in EU-15), where the number of farms will be reduced fast and radically by their physical elimination (sale or lease to neighbours).

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TECHNICO-ECONOMICAL STUDY OF GPS GUIDING SYSTEMS IN AGRICULTURE

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Keywords : GPS, Guiding system, added value, paying off

Abstract

A GPS guiding system helps the driver to keep a chosen working width and then to reduce the overlap thanks to a higher precision. It facilitates and accelerates the farmer's work as marking out the field, spraying, spreading… The GPS guiding systems currently marketed with a medium precision (< 20-30 cm) are numerous and their prices vary from ± 1 500 € to 8 000 € according to their precision and functionalities. Some other systems are even more expensive, but they are equipped with a RTK station and allow auto-guiding with higher precision (< 5 cm). The study aims to calculate the added value of the current GPS systems and to determine if the investment is financially justified. The calculation of the added value is based on the potential saving of fertilizers and pesticides due to the reduction of the overlaps or gaps.

In order to form a good base of comparison, the actual overlap with and without GPS systems, has been measured directly in 85 fields for different crops : grass, wheat, barley, maize, sugar beet and potato.

The model of calculation takes numerous parameters into account related to the GPS guiding system itself, the crops, the used material, manpower… The added value of several guiding system has been determined for the studied crops as well

as for 4 typical farms : grassland, mixed (breeding and crops), medium and large crops farm.

The study shows that the GPS presents the highest added value for the grass production where the actual overlapping and the input costs are more important. Therefore, a 60 ha grassland farm (2/3 meadows) can already pay off a GPS system of 2500 € (precision of 30 cm) within 5 years. The large crops farm (480 ha) can easily pay off a more precise system of 8000 €. It is possible to increase the precision of the guiding system subscribing to a paying signal. But the cost of the subscription (1000 €/year) can be paid off only by the very large farms.

Introduction

Positioning system by GPS (Global Positioning System) takes a great importance in our daily life. In Agriculture also several applications have been developed and meet an increasing success. For the moment, the current and functioning applications are land surveying, parcel's mapping and simple or auto-guiding. GPS guiding systems help the driver to keep a chosen working width while reducing the overlap (spraying, spreading, seeding…). That would allow to improve the production management and to reduce the impact on the environment.

GPS used with a differential correction system (dGPS) allows to reach a precision within 20-30 cm. Huyghebaert & al (2008) shows that the nominal precision announced by the manufacturer is often on the rendezvous. Moreover, usual GPS guiding system should be reserved to large machines (spraying, spreading…). GPS guiding used with small machines (seeding, planting…) need a more precise correction (< 5 cm) as RTK which is also much more expensive.

Prices of current GPS guiding systems vary from ± 1 500 € to 8 000 € according to their precision and functionalities. Moreover, for some of them, the signal rental costs 800 € to 1000 € per year. At the end the total cost of the GPS guiding is not to be sneezed at.

The question is, GPS guiding systems are they useful production tools or do they remind costly gadgets? This study aims to determine the economical added value of the GPS.

Materials and Methods

This study based the calculation of the GPS's added value only on the savings of the production costs due to the reduction of the overlaps of gaps during pesticides and fertilizer applications. Other savings or gains (e.g. : reduction of the labour, increasing of the working period, precision farming…) would be taken into account, but they are hardly quantifiable. Also, other works (e.g. : seeding, manure application…) would be considered, but they are not relevant with the use of a current precision GPS or the use of a guiding system at all.

We define an overlap when the actual working width (Wa) is smaller than the nominal working width (Wn). An overlap induces a waste of inputs (fertilizer and pesticides) and an increase of the running cost of the materials (tractor, spreader and sprayer).

On the opposite, a gap is produced when Wa > Wn (Figure 1). Economically speaking, the gap is beneficial since it allows to save inputs and to decrease the running costs. On practical and agronomical point of view, a gap is also undesirable since it induces an efficacy and yield drop. Therefore, we consider, in the GPS's added value, the yield losses when gaps occur.
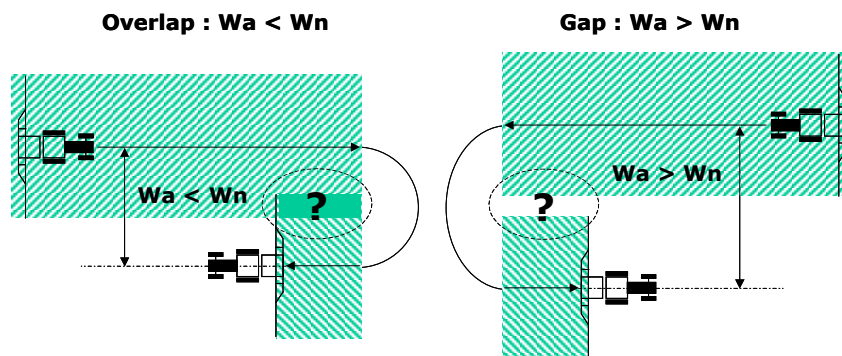
Figure 1 : Description of overlaps and gaps during inputs application

Calculation of the GPS's added value is based above all on the actual working precision without the use of a GPS guiding system. Using a GPS guiding system improves the working precision as précised Huyghebaert et al (2007). Depending on this improvement, the GPS's added value and its paying-off will be more or less great. To determine this "traditional" working precision, 1 275 actual working widths have been measured directly in 85 fields with different crops (permanent or mowed meadow, barley, wheat, ploughed land, intermediate crop,…). Each field was divided into three blocks where 5 working widths have been measured.

A model has been developed under Excel software to calculate the added value of the GPS guiding system. At the input of the model, five main parameters are defined :

1° Studied GPS guiding system which is characterised by its investment cost, its precision (given by the manufacturer), its running costs (depreciation within 5 years, annual depreciation rate of 20%, interests rate of 2,1%, insurance, reparations) and the repartition of overlaps and gaps based on the assumption that the GPS guiding system gives the absolute precision 40 % of the working time, generates overlap and gaps of a width equal to the given precision for 30 % of the working time.

2° Crops and crops rotation of the farm which are characterised by the proportion of each crop in the farm, the crops yield, the product prices and the cultivation parameters (operation, material, inputs costs…).

3° Machines uses for the inputs application (tractor, spreader and sprayer). Different units "tractor-machine" have been defined and their running costs (investment, depreciation, reparation) have been calculated with a sub-model.

4° Labour costs have been defined on the basis of Belgian statistics.

5° The working precision reached without the use of GPS guiding system. This parameter is based on the preliminary study.

At the output, the model gives the added value of the studied GPS guiding system for each particular crop or for each defined farm.

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Research Results

Preliminary study on the traditional working precision
The results on working precision without GPS guiding system, allows to differentiate the studied crops into two categories :

- crops with markers as cereals where the driver has at his disposal lines (seed-drills or seeding lines) allowing him to determine the right distance between two tracks.
- crops without markers as meadow, ploughing… where the driver hasn't visual marks allowing him to keep the right track and working width,

For crops with markers, the overlap of the inputs application reaches on average **– 2,65** % of the working width. Figure 2 shows the frequency distribution of the working precision expressed in percent of the nominal working width.
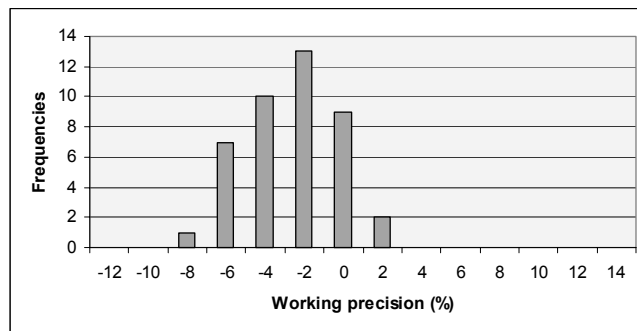
Figure 2 : Frequency distribution of the working precision (%) for crops with markers

For crops without markers, the overlap reaches on average **–5,30** %. The frequency distribution of the working precision (Figure 3) is much more spread than the one for crops with markers. Some drivers generate overlap higher than 30 % of the actual working width.
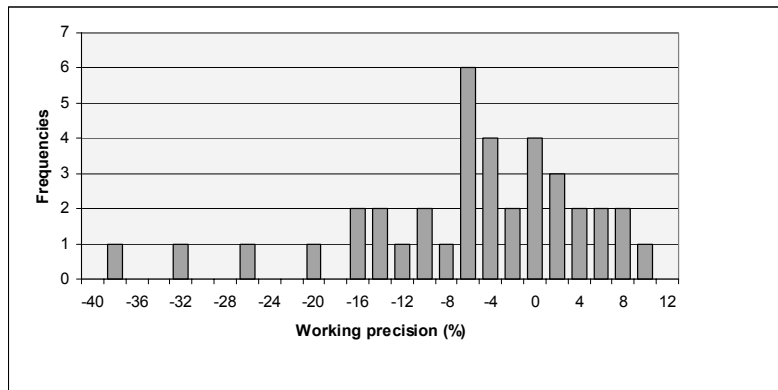
Figure 3 : Frequency distribution of the working precision (%) for crops without markers

Added value of the GPS guiding system for each crop

The added value (€/ha) has been calculated for different crops with the model. For maize, sugar beets and potatoes, only inputs applications done before the sowing have been taken into consideration. For those crops, GPS guiding system is useless after the sowing since the driver will never crush the plants lines. For the other studied crops, all inputs applications done during the whole cultivation period have been taken into consideration. Figure 4 gives the added value (€/ha) for the studied crops in function of the precision (m) of the GPS guiding system.
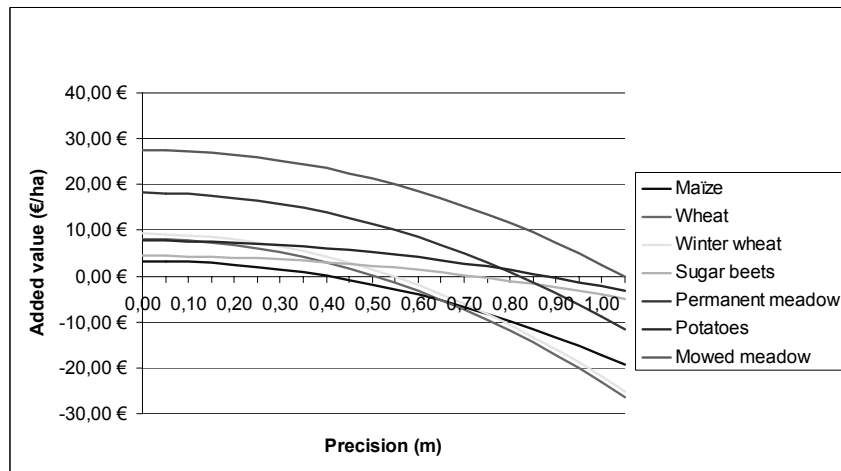
Figure 4 : Added value (€/ha) of GPS guiding system for different crops in function of the its precision

The added value is clearly linked to the inputs costs and the actual working precision without GPS guiding system. For that reason, mowed meadow presents the highest added value since the inputs costs (fertilizer) are high and the precision without GPS is low (-5,6% of the working width).

Except for the permanent crops (meadow), the GPS guiding system must have a precision of at least 0,4 m in order to give a positive added value.

Added value of the GPS guiding system for different typical farms

The added value has been calculated for 6 guiding systems whom the precision and investment price were decreasing. Table 1 gives the characteristics of the studied guiding systems (data 2007).

Table 1 : Characteristics, precision and investment price of the 6 studied GPS guiding systems (2007)

Model	Mark	Precision (cm)	Signal correction	Price (€) excl. VAT	Signal rental (€) excl. VAT
Autofarm A5	Satplan	3	RTK	36 650	Free
Green Star 2	John Deere	10	SF2	7 324	1 000
EZ Guide 500	Trimble	20	Omnistar XP	4 030	800
Green Star 1	John Deere	25	SF1	4 705	Free
Cultiva ATC	Satplan	30	Egnos	4 975	Free
Centerline 220	Teejet	30	Egnos	1 600	Free

It is obvious that some GPS systems are too sophisticated to be used only as guiding system for inputs applications. They could be used for other purpose and paid off on other cultivation works (auto-guiding, sowing, seeding, planting…).

The GPS's added value has been evaluated for four typical farms (grassland, mixed (breeding and crops), medium and large crops farms), considering a five years depreciation.

Figure 5 shows the results for the grassland farm of 60 ha (10 ha of wheat, 10 ha of maize, 30 ha of permanent meadows and 10 ha of mowed meadow) equipped with a tractor of 100 hp, sprayer and spreader of 18 m. The added value increases with the precision of the GPS system, but also its yearly costs since the investment cost is strongly linked to the precision. One observes that the main part

of the GPS's added value comes from the meadows (permanent and mowed). For this grassland farm of 60 ha, only low price GPS guiding system (< 2100 €) with a 30 cm precision could be paid off within 5 years.
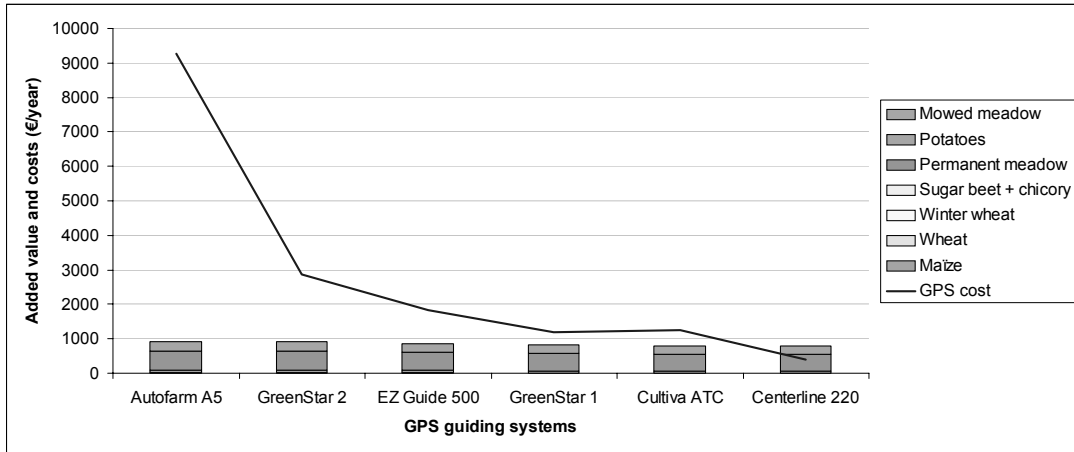
Figure 5 : Added value and costs of 6 GPS guiding systems (€/year) for a 60 ha grassland farm

Figure 6 shows the results for the large crops farm 480 ha (220 ha of wheat, 30 ha of winter wheat, 120 ha of potatoes, 110 ha of sugar beet or chicory) equipped with a tractor of 150 hp, sprayer and spreader of 36 m. This farm is able to pay off within 5 years all GPS guiding system whatever their investment costs, except the RTK.
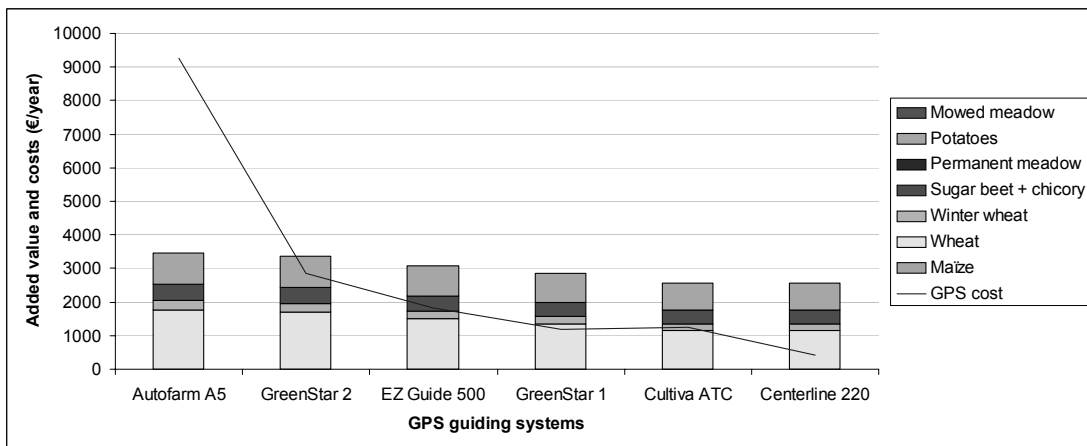
Figure 6 : Added value and costs of 6 GPS guiding systems (€/year) for a 480 ha crops farm

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Discussion and Conclusions

This study demonstrates that the GPS guiding system could be an useful production tool giving, under certain conditions, financial feedback.

First of all, to determine the paying off of the GPS, the actual working precision that the drivers are able to generate without GPS guiding systems has been measured directly in the field. Results showed that the drivers don't keep the nominal working width, but create on average an overlap of 2,65 %, for crops with markers (cereals), and 5,30 %, for crops without markers (meadows, ploughed land,…). Based on those results, GPS guiding systems could give an added value reducing the overlaps and indirectly the production costs.

An Excel application has been developed to calculate the added value of the GPS guiding systems based on the savings and gains that it could generate during the pesticides and fertilizer applications. Other advantages given by the GPS could be taken into account, but they are hardly quantifiable. The calculation considers the running costs of the machinery, cropping plan, actual inputs prices… The added value of different GPS guiding systems commonly marketed in Belgium has been calculated for different crops (meadows, cereals, maize, sugar beets…) and different types and sizes of farms.

The highest GPS's added-value is observed for crops presenting high costs of inputs (pesticides and fertilizer) and low working precision without GPS guiding system, e.g. : meadows. Therefore a little grassland farm of 60 ha could already pay off within 5 years a GPS guiding system of 2100 € and with a precision of 30 cm, only with the savings made on inputs (pesticides and fertilizer).
More expensive GPS guiding system (8000 €) presenting higher precision (10 to 20 cm) could be paid off by larger crops farms (480 ha). Also signal rental (1000/year) could be only paid off by large crop farms.

Finally, very expensive guiding systems, as RTK, are hardly justifiable if the paying off calculation is only based on the overlap reduction. Other savings or advantages must be taken into consideration to justify economically such an investment.

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IMPACT OF THE USE OF TWO DIFFERENT METHODS TO APPRECIATE THE DEPRECIATION OF MACHINERY ON TOTAL PRODUCTION COSTS AND ON FARM INCOME IN WALLONIA (SOUTH OF BELGIUM)

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Abstract

Based on the Farm Accounting Data Network of the Walloon region (Belgium), two methods to estimate the depreciation costs of agricultural machines are used and compared. The first one takes into consideration the purchasing price of the machines and gives the lowest results. However, the prices are changing with time and generally (but not always!) go up. So, it can be justified to use replacement costs. As a consequence, depreciation costs for machinery are higher than in the previous method. However, the statistical analysis done on a sample of Walloon farms shows that the impact on the total costs and on farm income is lower than 2%, as machinery represents only 37% of the assets which can be depreciated and 20% of the total farm assets (including land). The impact varies according to the farms' typology, but is always small. So, to use the replacement value of machines is theoretically more relevant than to use the purchasing value, but the results are not very significantly different and the calculation is less simple. So, the linear depreciation method taking the purchasing price into account can still be used.

Introduction

In Wallonia, agriculture is heavily capitalized and the methods which are used to calculate the depreciation of machinery and buildings can have some influence on farm income assessment.

The Walloon administration must give statistical information to the European Commission about the profitability of its agriculture, through the Farm Accounting Data Network (FADN). Nowadays, the FADN's method uses the value of renewal of the machinery in order to calculate the depreciation.

On another side, there is a necessity to harmonize the three farm accounting data networks existing in Wallonia and financially supported by the regional government: the network of the administration, the network of the farmers' union and the network of the animal breeding association.

In Walloon agriculture, machinery represents 37% of the assets which can be depreciated and 20% of total assets.

The objective of the study is to compare the impact of the use of two methods of depreciation (one considering the purchase value of the machinery and the other one taking into account the value of renewal) on the total costs of farming and on farm income. The first method,based on the purchase value, is the easiest, the depreciation value being constant over years.However, it does not take into account the significant technical improvements which can occur.The second method takes into account the evolution and is so more adapted to reality, but it needs to know the appropriate index and the amount of depreciation changes every year, making the calculation more time consuming.

Materials and Methods

The calculations have been made on a sample of 30 farmers belonging to the network of the administration and representing the different agricultural regions. The data have been collected during the year 2004, with a complete census of the machines (tractors, harvesters, sprayers, ploughs …).

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Some data were missing and had to be estimated.

The total costs of farming and the farm income have been calculated 1) using the purchase value of machinery and 2) using the value of renewal of the machinery, which is the purchase value multiplied by a coefficient defined by the National Institute of Statistics. The coefficient (index) is based on the evolution of prices, on a yearly basis, of the main types of machinery used, each type having a specific weight in the total.For example, if the index is 1.10 for the year y+2, it means that the price index for machinery in general increased by 10% compared to the reference year y.

Research Results and Discussion

The results are presented in table 1.

When the farm income is calculated, it appears to reach 24,245 € per working unit when the purchase value is used and 22,987 € per working unit when the value of renewal is considered.

On average, the cost of machinery depreciation represents 7.36% of total costs when the purchase value is used and 7.76% when the value of renewal is used, as a mean.

However, the shares are very variable from farm to farm. This is due to the different types of production and production systems (for example "zero grazing" versus "full grazing" for dairy production), and also to the age of machinery.Young farmers have new machinery and are more indebted than elder farmers, who use more machinery already depreciated, but still working (so, less financial costs for the latest).

If we consider now the share of machinery in the value of the total assets of the farm, we reach 18.91% and 19.59% when we take into account the purchase value and the value of renewal, respectively, with large variations between farms.

Table 1 : Share of depreciation costs of machinery in the total costs of farming, according to the calculation method of depreciation

Farm number	Purchase value			Value of renewal		
	Depreciation costs (1)	Total costs (2)	(1)/(2)	Depreciation costs (1)	Total costs (2)	(1)/(2)
1	6237,41	389568,82	1,60%	7495,29	391171,18	1,92%
2	17633,67	360772,56	4,89%	19884,11	363557,39	5,47%
3	13668,09	304158,37	4,49%	15081,57	305947,03	4,93%
4	8415,06	150613,97	5,59%	9749,7	152199,72	6,41%
5	90917,89	393722,76	23,09%	92311,13	396417,05	23,29%
6	2082,31	99616,79	2,09%	2293,51	99890,11	2,30%
7	7391,17	203401,08	3,63%	8479,33	204810,97	4,14%
8	12788,76	581963,62	2,20%	13599,98	583199,54	2,33%
9	4716,82	62778,95	7,51%	5148,84	63353,7	8,13%
10	5858,7	161166,27	3,64%	6882,66	162488,48	4,24%
11	11911,3	260110,12	4,58%	12843,8	261093,2	4,92%
12	10609,86	172502,53	6,15%	12641,6	174768,93	7,23%
13	10089,7	249568,74	4,04%	11455,08	251026,09	4,56%
14	19236,88	170465,81	11,28%	19542,41	170858,66	11,44%
15	22177,1	70990,13	31,24%	22489,43	71421,29	31,49%
16	7375,16	742233,13	0,99%	7625,82	742661,34	1,03%
17	27099,15	224953,75	12,05%	27955,44	225910,45	12,37%
18	2409,8	106174	2,27%	2885,39	106705,05	2,70%
19	4124,01	151196,01	2,73%	6001,7	153291,3	3,92%
20	7034,95	373636,93	1,88%	7606,82	374421,93	2,03%
21	18776,99	681517,12	2,76%	21448,2	684605,3	3,13%
22	29418,63	301028,41	9,77%	29663,11	301287,15	9,85%
23	26415,06	211061,07	12,52%	28694,03	214696,73	13,36%
24	32324,01	231706,01	13,95%	32587,4	232823,72	14,00%
25	29977,8	220884,21	13,57%	30500,75	221488,43	13,77%
26	12121,68	252344,54	4,80%	13720,24	254384,76	5,39%
27	12121,68	252344,54	4,80%	13720,24	254384,76	5,39%
28	7479,72	110707,8	6,76%	7482,4	110711,57	6,76%
29	3304,56	190683,82	1,73%	3431,55	190814,99	1,80%
30	14792,45	125875,18	11,75%	15614,7	127077,8	12,29%
Mean			**7,36%**			**7,76%**

Conclusions

The use of the value of renewal in spite of the purchase value in order to calculate machinery depreciation costs increases the total costs of farming and reduces farm income in a small proportion.

Though the first method is now compulsory for the European Farm Accounting Data Network, its use is questionable as it requests more calculations than the second method.

Acknowledgements

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THE ANALYSIS OF LABOUR EXPENDITURES AND STRUCTURE OF CROPS ON DIFFERENT TYPES OF FAMILY FARMS

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Keywords : labour expenditures, family farms, SGM, European Size Unit, structure of crops

Abstract

The analysis of expenditures of work was executed in 39 Polish family farms. It was divided in 5 groups according to farm typology. The structure of production was qualified in the individual groups also. Analysis showed that the largest expenditures of men's work existed in Specialist farms. The cereals in structure of production is predominant.

Introduction

The labour expenditures is one of the factors that determine the profitability of agricultural production. Therefore finding their size and structure can be useful to calculate the production costs in different groups of farms. The qualification of labour expenditures in the different groups of farms determined on the typology based on Standard Gross Margin is the aim of this work.

Materials and Methods

Our research analyses 39 family farms with different farming systems during 2002-2003. All farms were categorized in the following farm types (EU definition based on Standard Gross Margin): *Specialist field crops, Specialist grazing livestock, Specialist granivores, Mixed livestock holdings, Mixed crops –livestock* (Community typology for agricultural holdings (85/377/EEC)).

Research Results

The largest number of farms were in group *Specialist granivores* (13 farms). The smallest number was in group *Specialist field crops* (5 farms). Farms in the group *Specialist granivores* got average 77.1 European Size Unit, which was the largest value among the analysed groups (tab.1). The labour expenditures level was different, depending on farms type. The highest level was observed in farms from the group *Specialist grazing livestock* (195.9 man-hour per ha). The average area of cultivation of farms in this group was 22.2 ha, which is the smallest area among analysed groups. The expenditures of machines energy were different with the average of 1613 kWh per ha for 39 farms.

Table 1. Statistical information on the analysed farms

Specification	Unit	The type of farms					Average for 39 farms
		Field crops	Specialist grazing livestock	Specialist granivores	Mixed livestock holdings	Mixed Crops/ Livestock	
Number of farms	-	5	6	13	9	6	39
Average area	ha	58.1	22.2	49.4	44.0	48.4	44.94
Standard Gross Margin	PLN·ha^{-1} PLN·person^{-1}	1309 34564	4225 40169	7488 141553	4230 69795	2887 59881	4718 84245
European Size Unit	ESU	15.8	19.5	77.1	38.8	29.1	44.2
Number of workers	persons·100 ha^{-1}	3.8	10.5	5.3	6.1	4.8	5.5
Expenditures (labour)	manhour·ha^{-1}	66.4	195.9	101.4	134.3	74.6	105.8
Expenditures (machines energy)	kWh·ha^{-1}	1389	1143	1746	1645	1714	1613

In the analysed group of 39 farms cereals constituted the largest part in the plant production – 72.4%. Meadows were the next - 12.8 % and vegetables constituted the smallest part (0.9 %) (fig.1).

In group *Specialist grazing livestock* constituted the largest part meadows. The sum of area of the meadows and the maize on silage constituted in this group over 50% of the whole farm area. In farms *Specialist granivores* cereals constituted 80% of plant production.
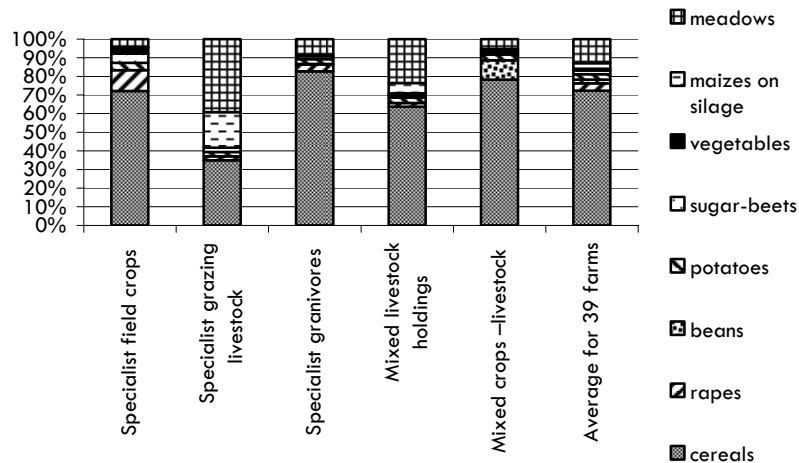
Figure 1: Structure of crops in groups

The value of Standard Gross Margin (SGM) per hectare increased along with the increase of labour expenditures per hectare of plant. The value of Pearson linear correlation coefficient (r = 0.48) proves the average level of correlation between labour expenditures and Standard Gross Margin (fig. 2).
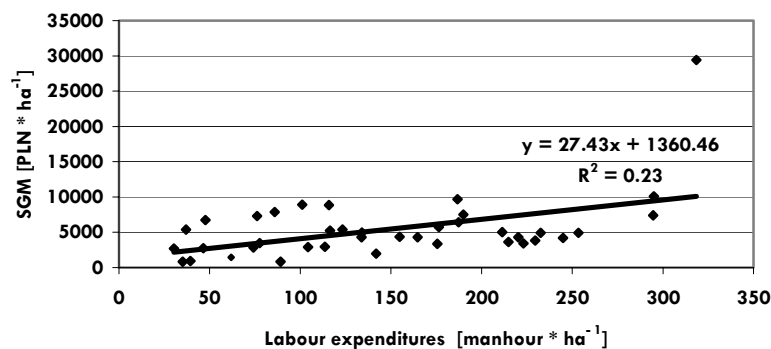
Figure 2: Standard Gross Margin and the labour expenditures

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Discussion and Conclusions

The analysis of expenditures of men's work in Polish farms, executed by Szeptycki and Wójcicki (2003) proves, that the level of expenditures of work increases along with the decrease of the surface of farms. Kowalski et al. (2002) also analysed the expenditures of work, proving that the most labour-consuming farms were directed on animal production farms. However Lorencowicz and Kocira (2002) dealing with the technologies in vegetal production affirmed that from among analysed plants the highest expenditures of work objectivise exist in the sugar-beet production.

The Standard Gross Margin increases along with the increase of labour expenditures. Cereals constituted the main crop in analysed farms. Specialist granivores farms have the highest level of Standard Gross Margin, while the labour expenditures are close to the average for the 39 farms group. The Specialist granivores farms bear also the highest level of labour expenditures.

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ECONOMIC ASPECTS OF POTATO STORAGE

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Keywords: potato storage, storage costs, investment, storage building

Abstract

The storage cost of potatoes is an important parameter to evaluate the profitability of the speculation within the farm. However, this aspect is often ignored by producers. During this study, storage costs were calculated for the three principal production types: processing potatoes, fresh market (or table) potatoes and seed potatoes.

Costs relating to the investment ranged from 196 to 390 €/ton of stored potatoes. The level of equipment influences the investment costs. For a building with a storage capacity of 1000 tons having an increasing level of equipment, the investment cost passes from 128 €/ton for the less equipped building to 263 €/ton for an insulated, ventilated and cooled building. Another factor to be taken into account is the size of the building which makes possible economies of scale. For a building equipped with a ventilation system and a thermal insulation, the estimated investment costs are of 377 €/ton for a capacity of 500 tons while they are of 178 €/ton for a building of 3 000 tons having the same equipment. The annual costs for the storage calculated for the 3 types of production vary between 25.60 and 55.30 €/year/ton. This economic analysis shows the importance of the variability of the investments, and thus, of the potatoes storage costs according to the type of production. It highlights high costs related to potato storage in specific buildings adapted for the preserving of the quality.

Introduction

The potato crop is the 5th most important crop in Belgium with 67,942 ha in 2007 (INS, 2008). The 3 main production types are processing potatoes, fresh market potatoes and seed potatoes. The cultivated area represents 5% of the total area used for agriculture in Belgium behind meadows (19%), wheat (15%), silage maize (12%) and sugar beets (6%). Furthermore, processing industries are well established with more than 2 million tons of potatoes processed each year in the country and a turnover of about 700 million € in 2006 (Belgapom, 2007).

The time gap between harvest and the moment when potatoes are used or processed makes their storage necessary. The duration of storage can vary from a few weeks till several months. The main aims for an optimal storing of potatoes are to maintain all their qualities, to limit weight losses and to prevent the development of diseases. The quality standards are specific for each production type. That results in different priority requirements, and thus, in practice, in a different type of storage (control of the storage, type of building and its equipment). This leads to an important variability among the building for potato storage in farms.

The storage cost of potatoes is an important parameter to evaluate the profitability of the speculation within the farm. However, this aspect is often ignored by producers. It must integrate fixed costs (investments, interests, taxes, insurances and annual maintenance) as well as variable costs (freezing of the capital during storage, labour, energy and weight losses during the storage).

Economic study
The economic study concerns the 3 main production types. For each of them, the investment for the construction of a new building and the total cost of storage were assessed.

Investment costs
An enquiry was made in 2007 to builders of potato storage facilities. The most important builders on the Belgian market gave cost prices of potato storage buildings following specifications.

For the same storage building (3 000 tons capacity, bulk storage, slatted floor) the prices among the 4 main Belgian builders varied from 150 to 180 €/ton of stored potatoes. Despite this variability, the costs given in the following figures are averages established on the data given by the main builders. The investment costs for different building types for potato storage are presented in the table-1.

Table 1: Investment costs for potato storage buildings

Building types	Investment costs *
Seed potato storage 500 tons capacity (26.6 m x 13.9 m), bulk storage on slatted floor, 3 parts, ventilation system, thermal insulation	195 000 € 390 €/ton of stored potatoes
Seed potatoes or fresh market potato storage 1000 tons capacity (30.8 m x 18.4 m), box storage, cooling system, thermal insulation	270 000 € (boxes for storage included) 270 €/ton of stored potatoes
Processing potato storage 1000 tons capacity (26.6 m x 19.3 m), bulk storage, above ground air duct, thermal insulation	195 466 € 196 €/ton of stored potatoes
Processing potato storage 2000 tons capacity (36.2 m x 26.0 m), bulk storage on slatted floor, ventilation system, thermal insulation	400 000 € 200 €/ton of stored potatoes

* All costs are VAT excluded and without any discount

The investment costs range from 196 to 390 €/ton of stored potatoes for the 4 most relevant buildings types in Belgium.

The level of equipment influences the investment cost (see table 2).

Because the level of equipment has a significant impact on the investment cost, every additional equipment should have a positive effect on the sale price of the product (better quality, less weight losses, less diseases) in order to be profitable.

For instance slatted floor, which represent an important over expenditure, will be preferably installed in big capacity buildings in order to allow their paying off on a bigger amount of potatoes. Furthermore, the positive impact of the better air distribution will be more noticeable for larger storages.

Table 2: Influence of the level of equipment on the investment cost (for a 1000 tons capacity building, bulk storage)

Level of equipment	Investment cost €/ton of stored potatoes	Increase in comparison to the less equipped building
Not insulated, without ventilation system	128	/
Insulated, without ventilation system	166	+ 30 %
Insulated, ventilation system (above ground air duct)	196	+ 53 %
Insulated, ventilation system (slatted floor)	228	+ 78 %
Insulated, ventilation system (slatted floor), cooling system	263	+ 106 %

The size of the buildings which allows economies of scale is also an important parameter influencing the investment cost (table 3).

Table 3: Influence of the building size on the investment cost (for a bulk storage insulated with a ventilation system)

Buildings size	Investment cost €/ton of stored potatoes	Increase in comparison to the smaller building
500 tons	377	/
1 000 tons	228	- 40 %
2 000 tons	200	- 47 %
3 000 tons	178	- 53 %

The buildings having a small capacity (500 tons) are the most expensive when brought back to the ton of stored potato and according to the builders they do not seem profitable. Even if the building size allows to make economies of scale (-53 % between a 500 tons capacity and a 3 000 tons capacity), it is important not to oversize the building. In fact, a building being never full will be hardly payed off and the fixed costs will increase compared to a smaller building.

Storage costs
The storage costs were calculated for the 4 most relevant building types in Belgium (see description table 1). The main costs taken into account in the calculation are presented in table 4.

Table 4: Main costs included in the total storage cost

	Costs	Assumption for calculation
Fixed costs	Depreciation	Linear depreciation, 20 years
	Interests	5%
	Taxes	Belgian taxes (RC and precompte)
	Insurances	Fire insurance for building and potatoes
	Annual maintenance	Cleaning and disinfection
Variable costs	Freezing of the capital during storage	3% on the value of the stored product (seed potatoes : 30 €/100 kg, fresh market potatoes : 15 €/100 kg, processing potatoes : 8,5 €/100 kg)
	Labour for storage management and supervision	1 hour/week during the storage (8 months for processing potatoes, 7 months for fresh market potatoes and 6 months for seed potatoes)
	Energy consumption (ventilation and cooling)	0.0741 €/kWh day rate 0.0331 €/kWh night rate
	Weight losses during storage	6% processing potatoes 6 % fresh market potatoes 5% seed potatoes

Table 5: Storage costs in €/ton

Costs (€/ton)	Bulk storage 500 tons	Box storage 1000 tons	Bulk storage 1000 tons	Bulk storage 2000 tons
Depreciation and interests	28.72	19.90	14.41	14.75
Taxes, insurances, annual maintenance	5.66	6.93	3.70	3.23
Freezing of the capital	4.50	2.62	1.70	1.70
Labour	0.96	0.56	0.64	0.32
Energy	0.48	1.18	0.36	0.48
Weight losses	15.00	9.00	5.10	5.10
Total cost	55.30	40.20	25.90	25.60

The storage costs in smaller buildings are double compared to the ones in the 1 000 and 2 000 tons buildings. The observed variability is explained especially by the differences in the investment costs (the investment cost per ton is high) but also by the value of the stored product (freezing of the capital and weight losses). For buildings used for the storage of processing potatoes (1 000 and 2 000 tons), the storage cost is comparable because the economy of scale obtained in the 2 000 tons capacity compensate for the slatted floor costs.

It has to be noticed that other costs should also be taken into account like handling costs which depend on the equipment used. The cost was evaluated from 3.10 to 10.50 €/ton for bulk storage and from 3.70 to 11.90 €/ton for box storage. The cost linked to sprout inhibitor treatments (only for processing potatoes and fresh market potatoes) was also calculated. It varies from 4.44 to 5.09 €/ton treated. It depends on the formulation of the applied product thus on the application equipment (duster, sprayer or fogger).

Conclusions

This analysis shows the huge variability among investment costs and storage costs for the potato storage regarding the type of production. It highlights high costs related to the storage in specific buildings adapted for the preserving of the potato quality.

Sales prices of potatoes are very fluctuating, they depend on the production type, the offer and if the potatoes are sold under contract or on the free market. For example, prices on the free market for Bintje during the last 10 years have fluctuated between 3.82€/100 kg to 17.41€/100 kg.

In this context, the profitability of the storage is not reached every year. When a new investment is studied, the calculation has to be done with the prices of several years in order to assess the profitability on the entire depreciation period.

However, the possibilities to sell big quantities of potatoes during the harvesting period are limited (transport, processing capacity). However, the investment in a specific building for storage is the only way for the producer to speculate by keeping a product of quality in order to obtain better prices on the free market.

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GUIDE OF RUNNING COSTS FOR FARM EQUIPMENT: A SIMPLE TOOL FOR DECISION MAKING

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Keywords: running cost, farm equipment, agricultural machinery, online service, mechanization cost

Abstract

The Agricultural Engineering Department has developed a method to calculate the running costs for farm equipment. The main aim of this project is to propose this service online in order to make easier the updates and to increase the interactivity with the user. At the same time, the data are updated, new equipments are added and the calculations are improved.

When online, the guide of running costs allows calculating running costs of the most common farms equipments and the introduction of parameters by the user himself (purchase price, rate of interest, performance…). Then the calculated running costs are more adapted for each particular case. The running costs are divided into several parts (fuel consumption, maintenance, repairs, depreciation, interests, insurances/taxes and labour) which lead to know which part has the bigger influence on the total cost. Moreover, calculation can now be carried out for a complete agricultural site (1 tractor with 1 or 2 machines).

This tool allows an optimal choice of the farm equipment according to the situation of the user (agricultural area cultivated, annual utilization), and limits the unjustified investment. Several agricultural sites can be compared such as different forage harvesting chains, technique of sowing with or without tiling… The tool will be also useful to fix a rate when a farmer works for a third party.

Introduction

On average, in the Walloon Region, mechanization costs represent about 30% of the total overheads in a farm (DGA, 2006). Following the analysis of agricultural accountings (DGA, 2007), the average amount per farm is 352 € per hectare used for agriculture (AUA). These costs, depending on the farms type, range from 268 €/ha (beef farms) to 416 €/ha (dairy farms).

Mechanization costs are rising. In Walloon farms, between 2003 and 2006, the average increase represents 52 €/ha in average (DGA, 2006). This increase is due to different parameters which influence fixed costs as well as variable costs. The increase of iron which was multiplied by 4 since 2003 (Belgostat, 2008), has lead to an increase of cost price of agricultural machines. On the other hand, the increase of fuel cost (from about 0.3 €/litre in 2003 to 0.7 €/litre in 2008, Federal Public Service - Economy 2008) influences the variable costs through the consumption. Despite this situation, in Belgium, we still observe an "over mechanization" of farms and farmers are reluctant to share the purchasing of agricultural machineries.

Currently for Walloon and European agriculture, the mechanization investments are a major component of the cost prices of the agricultural products. The improvement of the competitiveness of the Walloon agriculture requires a rationalization of the mechanization costs and thus imposes an extreme rigour in case of new investment. If the choice rests on technical criteria, an analysis of the profitability of the new investment must be carried out.

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Material and Method

The running cost is the cost of utilization of a machine, it represents the amount of money it costs to use a machine. It is expressed in €/unit of utilization. These units are the ones usually used to describe the utilization of the machine, e.g. hours for a tractor, ha for most of the machines, load for a trailer... The real running cost is calculated after the use of the machine by adding all the charges. We have developed a method to calculate the running cost of a given machine before its purchase. The costs which are included in the calculations method are of two kinds:

- fixed costs (do not depend on the use of the machine) including depreciation, interests, taxes and insurance;
- variable costs (depend on the utilization of the machine) including maintenance, repairs and fuel consumption. The labour costs could also be added.

The parameters needed to calculate the different costs are obtained by enquiries inside the agricultural machinery market from professionals (farmers, agricultural contractors, importers, dealers, repairers and manufacturers). These enquiries were done during 2008, for each machine type, for the most important brands available on the Belgian market. The table 1 summarizes the data that have been collected during the enquiries. These data are put together in a database which is the base on which the program runs for the running cost calculation.

The module of running cost calculation is programmed in PHP, MySql, Javascript and Ajax. It is integrated in a website with a friendly interface allowing easier utilization. The running cost calculator will be available in May 2009 through the general website of CRA-W (www.cra.wallonie.be) in 4 languages (French, Dutch, German and English).

Table 1: Data collection to support the running cost calculator

Data	Source
Cost price of the machine and its main options (€ taxes included)	Enquiries from importers, dealers, manufacturers
Technical life of the machine (hours). Number of hours the machine can work in its entire life	Enquiries from importers, dealers, farmers
Maximum depreciation duration (year) and residual value of the machine (% cost price of the machine)	Enquiries from the second-hand market
Interest and discounting rates (%)	Enquiries from banks
Maintenance and repairs (% cost price of the machine)	Manufacturer's instructions and enquiries from farmers, agricultural contractors, repairers
Taxes (€ taxes included)	Traffic taxes
Insurance (% cost price of the machine)	Enquiries from insurance companies
Parameters to determine the fuel consumption	Results from tractor test bench and field measurements
Fuel price (€/l)	Federal public service – economy, Belgostat
Performance of the machine in unit*/hour	Results of performances tests
Labour cost (€/hour)	Average cost for a qualified worker

* depends on the selected machine: unit usually used to describe the utilization of the machine, e.g. hours for tractors, ha for many machines, load for trailer…

The utilization of the running cost calculator follows 3 steps:

- selection of the number of machines and the type of machines (main characteristics and options) inside drop-down lists;
- presentation of the parameters coming from the database used for the running cost calculation. At this point, the user can change these parameters if they are not adapted to his situation. For example, the cost prices, the performance of the machine, the annual utilization…;
- calculation of the running cost and presentation of the result in €/unit and €/year. The total running cost is also divided into its main components and an advice is given regarding the profitability of the investment.

Utilization of the running costs

The running cost can be used as a tool for decision making to compare different equipments or agricultural works and to assess the profitability. Furthermore, the influence of some parameters on the running cost can also be evaluated.
Comparison with agricultural contractor's prices and influence of the annual utilization
The figure 1 presents the running cost obtained for a combine (330 hp, 6 straw walkers, 2.3 ha/hour, 200 ha/year).
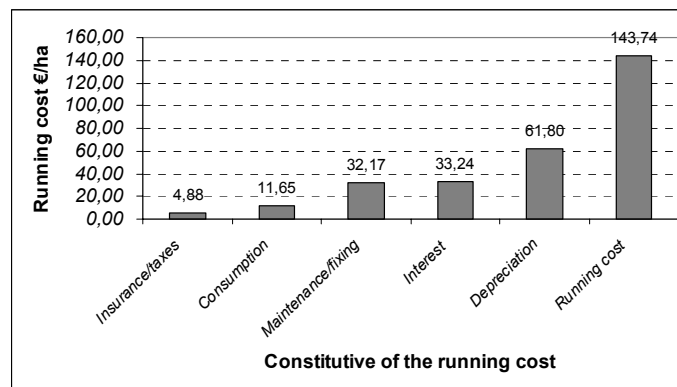
Figure 1: Running cost for a combine

The total running cost of this combine is 143.74 €/ha (without labour). This amount can be compared to the price of an agricultural contractor which is about 125 €/ha (Belgium, 2008). In this situation, the user could consider to increase the utilization of the combine in order to decrease the cost of utilization (see figure 2). For an annual utilization over 250 ha/year, the running cost of the combine gets through 125 €/ha which is the cost of an agricultural contractor.
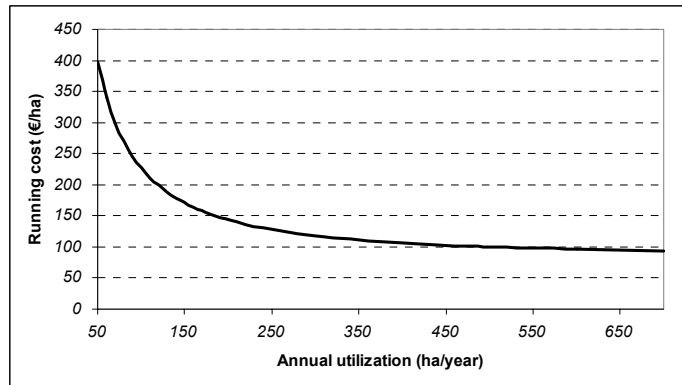
Figure 2: Influence of the annual utilization on the running cost (combine, 330 hp)

Comparison of agricultural works

The tool is also useful to compare different types of work. For example we used the calculation method in order to determine the harvesting cost of grass forage for different techniques (figure 3).
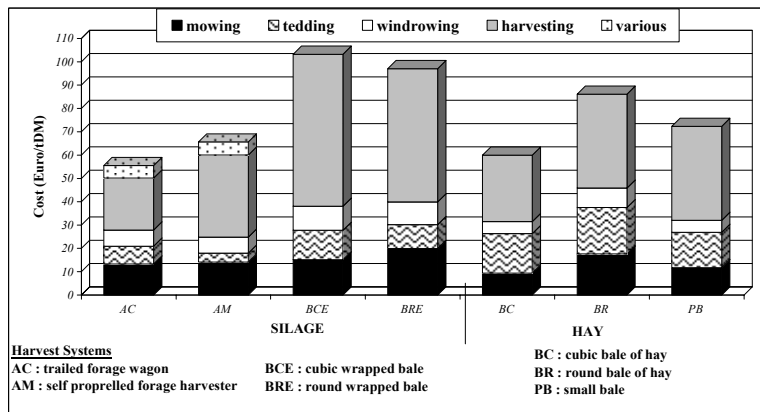
Figure 3: Comparison of forage harvesting systems

The left part of the figure shows the forage harvesting for silage (trailed forage wagon, self propelled forage harvester, cubic wrapped bale, round wrapped bale) and the right part for hay (cubic bale of hay, round bale of hay, small bale). The total running cost is divided into different parts which form the total harvesting from mowing to harvesting itself (the "various" part represents the additives). For silage, the use of a trailed forage wagon leads to the lower running cost (55.53 €/ton of dry matter) compared to other systems.

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Influence of fuel cost

The increase of the fuel price can also be assessed by using the running cost calculator. The figure 4 shows the evolution of the running cost for 3 different fuel prices. For a fuel price of 0.3 €/l (as it was in 2003), the cost due to the consumption is 4.5 €/hour whereas the current fuel cost (with a fuel price of 0.7 €/l) is about 10.5€/hour. It is important to notice that the share of the fuel cost inside the total running cost is also rising.
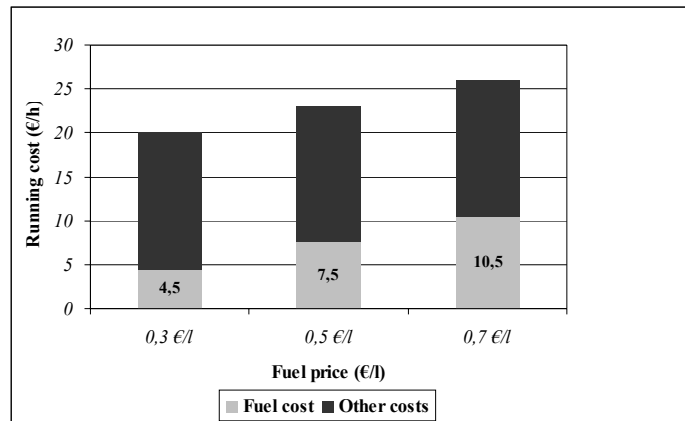
Figure 4: Influence of the fuels cost on the running cost (tractor)

Conclusions

The running cost is an essential parameter allowing to assess the profitability of a new investment. It is also useful to compare different equipments or types of work. The calculation of the running cost before the investment is a way to make an optimal choice of the farm equipment according to the situation of the user and also to limit the unjustified investment.

The development of a new tool available on Internet offers many advantages, such as, more interactions with the user, easier management and update, automatic calculation of the running cost of a set of machines, printing of the results with details.

Acknowledgements

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SUSTAINABILITY OF AGRICULTURAL PRODUCTION PROCESS CONSIDERING MATERIAL AND ENERGY INPUT LEVEL

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Keywords: sustainable agriculture, sustainable agriculture, material and energy inputs, sustainability indicators

Abstract

The level of sustainable agricultural production was analyzed considering the ESU index and the material and energy input level for 42 farms situated in different regions of Poland. Farms using above 25 ha AL and with a size above 16 ESU fulfill the sustainability aspects: ecological, economic and social ones.

Introduction

"Sustainable development" is about all human activities, our future, quality of food production and quality of human life. Because different groups of people have different needs, a lot of definitions for this term are used [Pretty, 1997]. In agriculture we describe *"Sustainable Agriculture"* as the balance of expectations of consumers and agricultural manufacturers in range: ecology, economics of agricultural production as well as socio-political equilibrium.

Important for initiating "*Sustainable Agriculture*" are farms with Good Agricultural Practices, where integrated production in every branch of the farm is applied. Every kind of production process is performed by applying scientific and technical progress and material and energetic expenses [Sawa at al., 2004a]. Sustainable agricultural production should consider economic, technical, technological, organizational as well as ecological and social aspects. In different cases (e.g.n

fertilization of plants) it is searching for the optimal balance. Sustainability indicators are useful in making decisions in agricultural practice.

Material and Methods

The estimation of sustainability of agricultural production process considering material and energy input level in 42 family farms is the objective of this paper. Those farms produce both vegetal and animal products and are situated in different regions of Poland. In this research it is assumed that the estimation of sustainable production process first of all refers to the ecological sustainability whose derivatives are: social sustainability and economic sustainability. The level of agricultural production and the parity income in reference to other sections of the national economy are important measures of economic farm situation. Independently of the ESU, calculated for selected family farms, we use following categories and indicators to measure of sustainability of agricultural production process:

environmental indicators - maintenance of the natural fertility of the soil and soil organic matter balance (ton/ha AL) [Kuś, Krasowicz, 2001];

social indicators - mechanization of labour processes, reducing the effort, securing the safety and comfort of life for agricultural producers (kWh/man hour);

economic indicators - the level of agricultural production in ESU or cereal units production per ha of agricultural land (CU/haAL).

Research Results

The estimation of indicators for sustainable production process in family farms is presented in this paper (table 1). The level of sustainable agricultural production was analyzed considering the ESU index and the number of ha of agricultural land (AL) for 42 farms situated in different regions of Poland. The farms were gathered on the basis of the class of their size of unit (ESU), determined by direct surplus (gross margin) obtained in the studied year [Sawa at al., 2004b].

The level of sustainability in the aspect of the ecological requirements is satisfying in farms included in the size class of over 16 ESU. Those farms produce a high level of the organic matter (over 0.4 tons/ha AL).

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Table 1: Indexes of sustainability of the production process in family farms investigated in 2004

Item	Units	European Size Unit (ESU)				Totally
		≤8	> 8 - ≤ 16	>16 - ≤ 40	> 40	
Number of evaluated farms	number	3	11	21	7	42
Agricultural land area on farm	ha AL	11.59	26.95	59.21	58.84	47.30
Material and energy expenses *(without agricultural production)*	PLN/ha AL	1123	1148	935	1175	1019
Environmental sustainability						
Soil organic matter balance - total	tons/ha AL	0.29	0.03	0.40	1.20	0.2
Social sustainability						
Inputs of man work	kWh/ha AL	1308	1426	1526	1803	565
Inputs of engine work	kWh/ man hours	5.9	9.7	18.3	16.4	15.5
Men's work per year	man hours	1275	1802	1764	2698	1908
Gradation of mechanization process.	%	55	66	78	77	76
Economic sustainability						
Agricultural market net output in cereal units (CU)	CU/ha AL CU/ man	36.5 211	47.9 615	46.5 983	87.7 2150	55.4 1042
European Size Unit	ESU	4.47	12.54	25.53	56.24	25.74

1) For the salary of 1460 PLN (net) outside the agricultural sectors of the national economy.

Estimation of social sustainability was made through estimating the unit outlays of man work, its equipment with the means of gradation of mechanization work process (%) and the annual hour man work for family members [Zaremba, 1985]. It was found out that the outlays of work (83-110 man hour/ha AL) are lower in larger farms, included within the size category of over 16 ESU. In this case, this is probably caused by the proper increase gradation of mechanization of the production process (from 55 to about 78%) and inputs of engine work (from 5.9 to 16.4, and even 18.3 kWh/man hour). However input of 2698 men's work in one year in the farms of the size class over 40 ESU is higher than admissible (2000 hour man work/worker/year or 36 000 MJ).

Concerning the economic sustainable agricultural process In the studied group of farms, the best production effects (87.7 CU/AL) were obtained by the farms from the category of size over 40 ESU. It is also worth emphasizing that the work efficiency expressed in CU/worker increased with the increased category of the farm's size unit (211-2150 CU/ man).

Discussion and Conclusions

Methods of determining the level of sustainability in agriculture, require the use of indicators that will be: - common, - understandable, - relevant to the estimation problem , - reliable, - comparable [Lamberton, 2000]. In this work three complementary indicators (ecological, social, economic), on particular farm production process, were used.

Increase of the size category expressed by ESU in the studied farms, with comparable material inputs, results in decreased energy input per ha of arable land, but also increased energetic equipment of work (kWh/man hour work) and the market net production per worker expressed in cereal units. At the same time, a comparable level of the gradation of mechanization process and a remarkable increase of the level of the organic matter reproduction are observed.

Practically farms larger than 16 ESU show a sustainable production process in the sphere of ecological, social and economic requirements. We found that farms using above 25 ha AL and with a size above 16 ESU fulfill the sustainability aspects (ecological, economic and social) .

Considering material and energy input level, we found the following changes (table 1): inputs of hour man work per ha AL " – " 50 %, inputs of hour engine work per ha AL "+" 38%, inputs of hour engine work kWh per 1 manhour "+" 280%, hour man work per year "+" 50% (1275 hours to 1908 hours), gradation of mechanizing of work process "+" 40%.

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ASSESSMENT OF OIL-SEED RAPE AGROPHAGES (PESTS AND DISEASES) IN DIFFERENT REGIONS OF POLAND

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Keywords: oil-seed pests and diseases, harmfulness assessment

Abstract

In Poland the harmfulness and occurrence of the agrophages have been monitored from 1950 onward. Last years the importance of oil-seed rape is increasing due to the European Union Directive 2003/30/WE and its role as a component of the bio-fuels. As the consequence the cultivation area of oil-seed rape is growing also in Poland.

Introduction

Climate changes together with increasing oil-seed rape production area may cause the development of new pests and diseases or intensity of the occurrence of the already existing ones. Therefore, the use of adequate varieties (high yield and resistant to agrophages) is very crucial.

In 2007 (in comparison to 2006) the favourable weather conditions improved the yield but the quality was affected by heavy rains. According to data collected by GUS (Central Statistical Office) the crop area was in 2007 796, 800 ha and was larger than in previous years.

One of the factors affecting yield height and quality is agrophages (pests and diseases) occurrence. Therefore monitoring is one of the most important sources of information regarding pests/diseases harmfulness assessment.

Materials and Methods

Monitoring comprises of field observation once a year in a specific period of time. The assessment is made separately for every pest or disease according to uniform methods (*Pruszyński et al.1993, Walczak et al. 1998, Węgorek et al. 1976, 1982*). The system of monitoring has to be objective and one has to be able to compare pest or disease harmfulness in different regions of Poland.

Observations are provided by the Plant Health and Food Security Inspection service and then send to Plant Protection Institute where all information is worked out and published at the end of the year (*Walczak et al. 2006*).

Oilseed rape agrophages rate is expressed as the percentage of infected or damaged stems, leaves, buds, siliques or entire plants depending on pest/disease. Every year the list of important pests and diseases which must be monitored is updated.

Research Results

In 2007 monitored oilseed rape diseases and pests consisted of: dry-rot of cabbage (*Leptosphaeria* spp.), rape blossom beetle (*Meligethes aeneus*), cabbage stem-weevil (*Ceutorhynchus quadridens*), stem-mining weevil (*Ceutorhynchus napi*), rape-seed weevil (*Ceutorhynchus assimilis*), brassica pod-midge (*Dasyneura brassicae*) – Maps 1-6 and Graphs 1-6.

In 2007 dry-rot of cabbage was observed commonly in Poland. In comparison to growing season 2006 an increase of disease intensity (in 2006 2.5% of infected winter wheat plants – average for Poland, in 2007 – 3.6%) was registered. Similarly to previous years at Northern parts of Poland

(zachodniopomorskie, pomorskie, warmińsko-mazurskie and kujawsko-pomorskie) the highest disease harmfulness was observed - map 1, graph 1.

In 2007 brown rust caused by fungi *Puccinia recondita* was observed commonly in Poland too. In comparison to vegetation season 2006 an increase of disease intensity (in 2006 8.3% of infected winter wheat plants, in 2007 – 9.8%) was registered. Similarly to last few years mainly at Southern and South- Eastern parts of Poland the highest disease harmfulness was observed.

One of the most important oil-seed rape pest in Polish conditions is rape blossom beetle (*Meligethes aeneus*). In vegetation season 2007 pest caused damages in whole Poland – 8.9% of damaged oil-seed buds (in 2006 – 10.5%). The highest pest occurrence was observed at regions of śląskie, podkarpackie, małopolskie, lubelskie and lubuskie (South-Eastern, Southern and partly Western parts of Poland) - map 2 , graph 2.

Cabbage stem-weevil (*Ceutorhynchus quadridens*), in 2007 were observed commonly in Poland but in small incidence (6.6% of damaged oil-seed rape plants). Since 1997 average for Poland (damages caused by pest) has been below many years average (17%). Higher cabbage stem-weevil incidence (higher than many years average) was noticed at South-Eastern (podkarpackie, lubelskie) and partly South-Western (dolnośląskie) regions- map 3 , graph 3.

Stem-mining weevil (*Ceutorhynchus napi*) was monitored in 2007 commonly in Poland and average for damaged oil-seed rape plants was 4.2%. Higher pest occurrence was observed in South-Eastern and partly South-Western regions- map 4 , graph 4.

Rapeseed weevil (*Ceutorhynchus assimilis*) and brassica pod-midge (*Dasyneura brassicae*) – called as a "siligues pests" were observed commonly in Poland. They are registered (except saddle gall-midge – it's occurrence is strictly connected with specific soil condition) at different levels of pests occurrence – maps 5-6, graphs 5-6.

Map1	Graph 1
Dry-rot of cabbage - Leptosphaeria spp. % of infected winter rape plants in 2007	Average % of infected winter rape plants by dry-rot of cabbage - Leptosphaeria spp. in Poland in 1991-2007

Map2	Graph 2
Rape blossom beetle - Meligethes aeneus F. % of damaged winter rape buds in 2007	Average % of damaged winter rape buds by rape blossom beetle - Meligethes aeneus F. in Poland in 1991-2007

Map3	Graph 3
Cabbage stem-weevil - Ceutorhynchus quadridens Panz. % of damaged winter rape plants in 2007	Average % of damaged plants by cabbage stem-weevil - Ceutorhynchus quadridens Panz. in Poland in 1991-2007

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Map4	Graph 4

Map 5	Graph 5

Map6	Graph 6
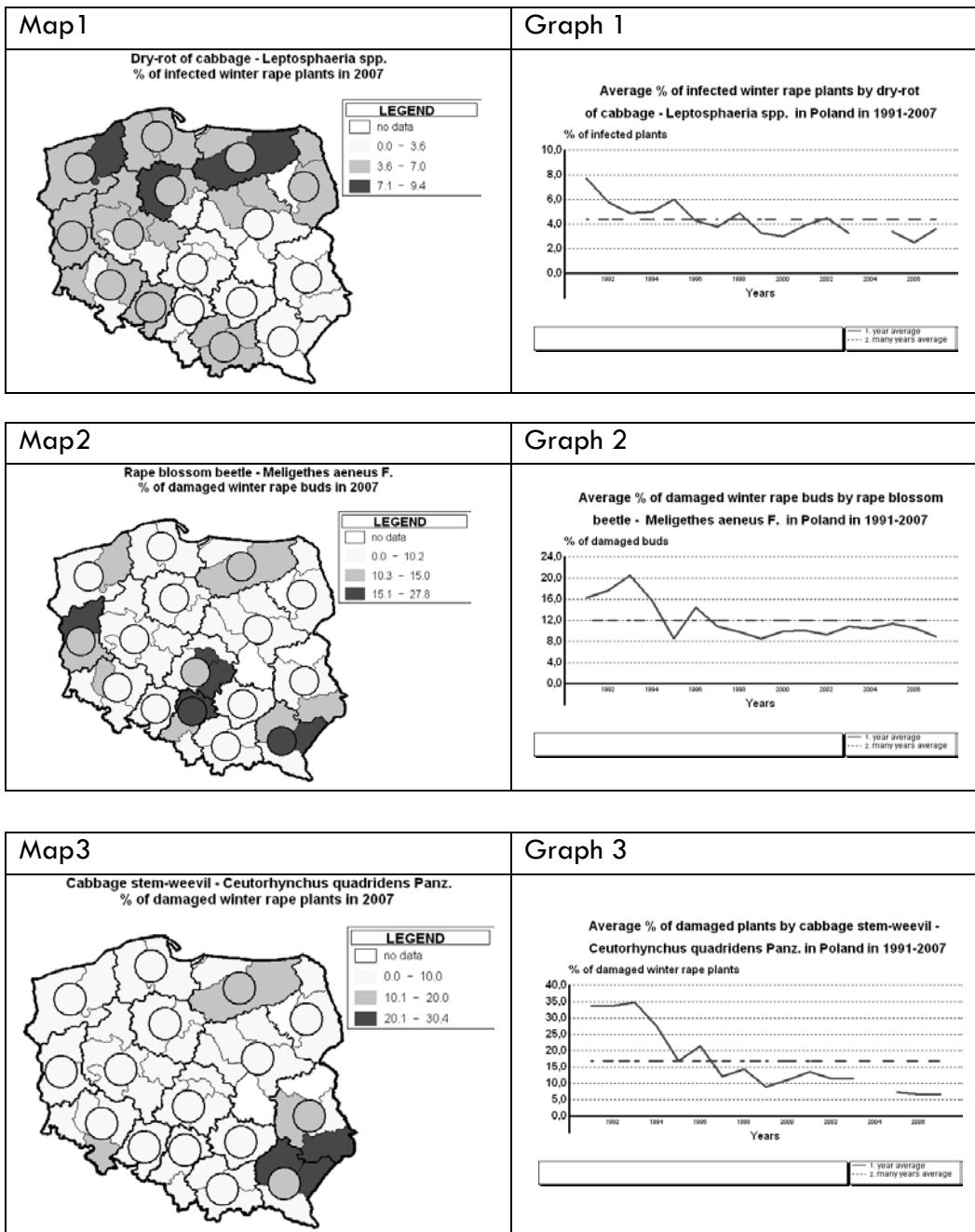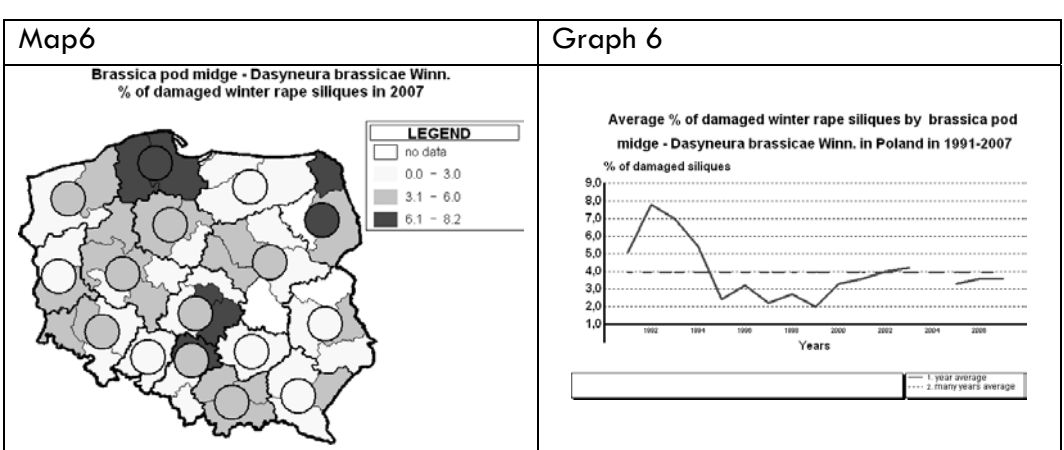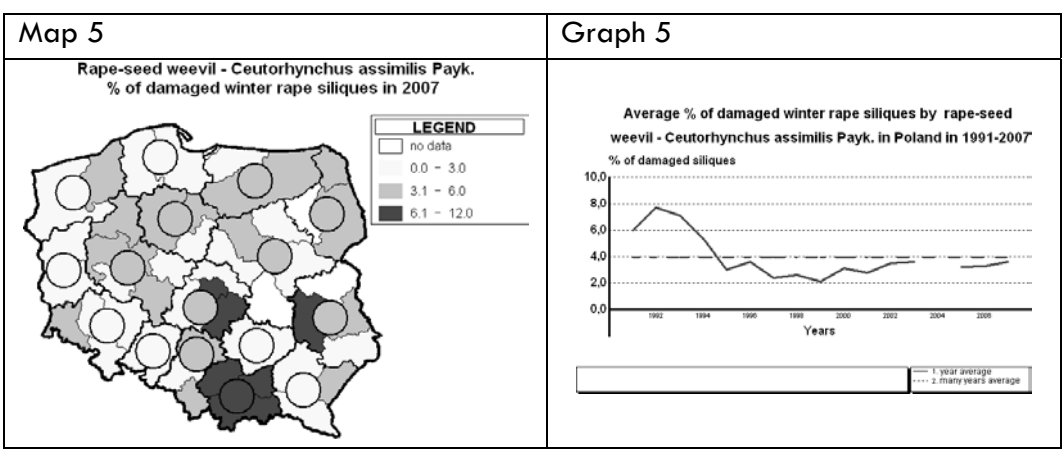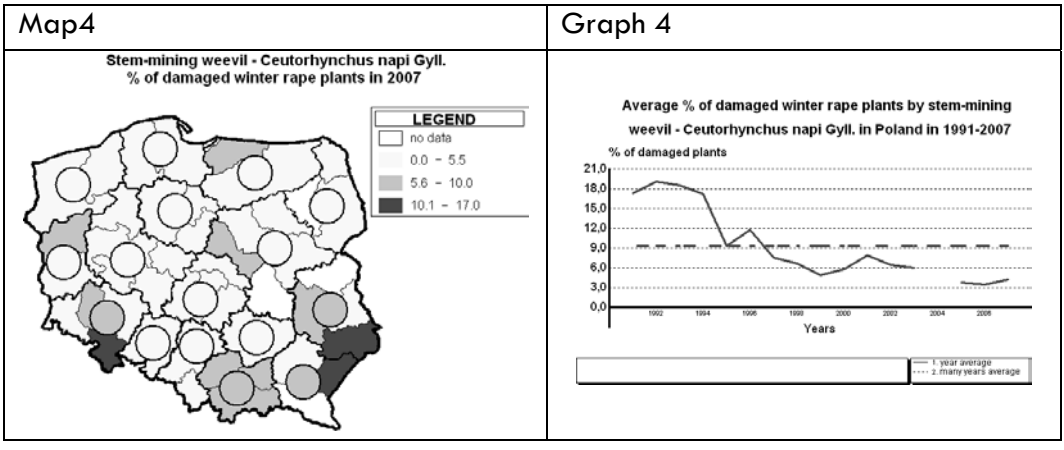
Discussion and Conclusions

1. Weather conditions in vegetation season 2007 caused an increase of dry-rot of cabbage occurrence.

2. Significant increase of cabbage stem-weevil, stem-mining weevil, rape-seed weevil and brassica pod midge was observed.

3. In Poland observation of economic significant agrophages enables to assess the health conditions of the agricultural plants and also determine the changes in the quantity of particular agrophage species.

4. Detailed monitoring helps to determine the changes in pests and disease occurrence.

5. Further study on biology and morphology of new pest species will enable to determine the prevention methods of their harmfulness.

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THE SCOPE OF IMPLEMENTATION OF MODERN MANAGEMENT CONCEPTS IN AGRICULTURAL ENTERPRISES IN POLAND
Part 1– TQM, OUTSOURCING

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Keywords: logistics management, TQM, Outsourcing, agricultural enterprise

Abstract.

The paper presents an analysis concerning an assessment of the implementation of modern management concepts in agricultural enterprises. The questionnaire prepared for the study and answered by 36 enterprises out of 60 polled, referred to issues connected e.g. with such concepts as TQM, Outsourcing. Investigations showed that although the problem of quality is considered a priority by enterprises, much is still to be done in case of certain TQM issues. For the concept of Outsourcing, both capital and contract outsourcing, it was found that still it is not commonly used in analyzed enterprises.

Introduction

Rapid civilization and technological progress, especially in the last 200 years, has resulted in a situation when business sciences are not always able to keep up with it. Thus management, especially strategic management, including also marketing and logistics strategies, has become this branch of business knowledge, which is characterized by an exceptionally dynamic development (Wojciechowski, 2007). Dynamism in this branch of science is also an effect of increasing competition on many markets and thus enterprises operating on those markets intensively search for a permanent and defensible competitive edge.

For this reason new concepts have been developed in management science, which are to a significant extent strategic in character. One of such approaches, introduced in mid-1980's, was logistics management (Christopher, 2000).

However, in recent years the increasing complexity of problems connected with the operation of an enterprise turned out to be so high that it has resulted in the development of many novel management concepts. Some of them are complementary to logistics. Concepts most closely related to logistics include first of all: Total Quality Management (TQM), Time Based Management (TBM), Lean Management (LM), Agile Manufacturing (AM), Outsourcing, Reengineering, Computer Integrated Manufacturing (CIM), Efficient Consumer Response (ECR) (Ciesielski, 2006, Gołembska, 2007, Witkowski, 2002, Wojciechowski, 2007).

The above-mentioned management concepts have been successfully implemented in enterprises in many industrial branches. Also in agricultural enterprises, being essential links in the food supply chain, managers see the need to improve their management system. It results from the increasing role of both vertical and horizontal integration in the agri-food industry, where the problems related to transport, warehousing, timely delivery, product quality and consumer satisfaction, etc. are becoming crucial. Thus the objective of the study was to assess the degree of implementation of the mentioned management concepts in agricultural enterprises.

Material and methods

We selected 60 enterprises with a minimum of 500 ha agricultural land (UAA) in the Wielkopolska region. We did not consider smaller farms because these farms have minor logistic problems. A questionnaire, including sets of questions identifying individual management concepts, was sent to all of them. The questionnaire consisted of two parts: descriptive information (9 questions) and the detailed part (45 questions).

Due to the limited scope of this paper (part 1) the presented results will concern two concepts, i.e. TQM and Outsourcing. In turn, results of investigations

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concerning the other concepts like Reengineering, CIM and ECR will be presented in the paper - part 2.

Information contained in the questionnaire, concerning granted certificates, participation in numerous training sessions, critical control points, analysis of quality parameters, information on employees - their involvement in activities improving the production process, motivation, development of professional skills and the application of customer satisfaction monitoring, will make it possible to determine which elements of the management system in the enterprise are an obstacle and which are consistent with the TQM concept, i.e. the quality-oriented management concept, aiming at ensuring customer satisfaction.

Another concept of modern logistics management, i.e. Outsourcing, is covered by questions concerning daughter companies, contracts with external service suppliers, the type of services, strategic partners and cooperation with contractors.

A total of 36 enterprises sent in the completed questionnaire forms. The structure of the investigated population was as follows:
- Group A: 500-1000 ha UAA – 25.0% (9 enterprises),
- Group B: 1001-2000 ha UAA – 41.6% (15 enterprises),
- Group C: over 2000 ha UAA – 33.4% (12 enterprises).

Research Results

TQM – Total quality management
In the conducted investigations, as far as TQM is concerned, only 6 enterprises gave positive answers to the question in the questionnaire concerning monitoring of customer satisfaction. However, before a given enterprise satisfies external customers it has satisfied (or at least it should) the needs of internal customers, i.e. employees. Thus such activities as trainings, professional development, the development of skills of employees, make it possible to realize the objectives of an enterprise. In this aspect, trainings aiming at the improvement of

qualifications of workers were found in 78% enterprises belonging to group A, in 53% enterprises in group B and 67% enterprises belonging to group C (fig.1). Trainings for workers are usually run once a year. They are in-service trainings connected with the introduction of new machinery, trainings in environmental protection as well as those in veterinary medicine.

In the concept of TQM considerable emphasis is placed on the analysis of quality parameters of processes and products. Among the 36 investigated enterprises critical control points of processes are defined in 8 enterprises (4 enterprises in group C, 3 enterprises in group B and 1 enterprise belonging to group A). The other entities did not give answers in this respect. Finished products are certified in 27% enterprises from group B, in 42% enterprises belonging to group C and in only 11% enterprises of group A. The quality of products is defined as high. The most frequently mentioned documents indicating a given quality standard include quality certificates, laboratory parameters, EU certificates, conformity certificates, opinions of buyers, appraisal of slaughter value, documents of the Provincial Inspectorate of Quality Monitoring or the County Veterinary Inspectorate.
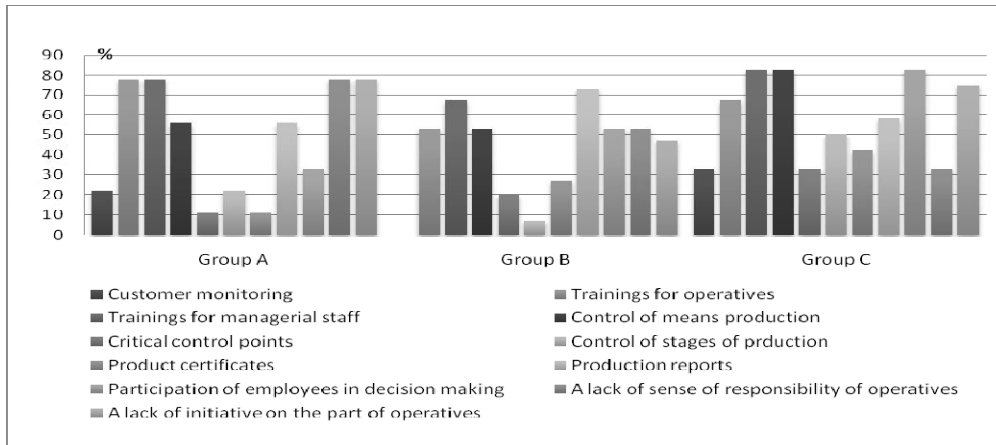
Figure 1. The degree of TQM implementation
Source: the authors' study

Another important aspect of TQM is the control of ordered means of production after they are supplied to the buyer. In enterprises belonging to group A such control is conducted by 56% entities. Observed quality defects of finished products are detected in most enterprises late - by the worker taking them during the production process or even after this process is completed. Two enterprises declared that such defects are also detected during the control activities at individual stages of production, and also by the worker directly involved in production. In the group of enterprises belonging to category B such control is run by a similar percentage of entities (53%). In this respect enterprises belonging to group C turn out to be best, as 83% entities conduct quality control of the means of production after they are delivered by the supplier. Also in this group relatively the biggest number of enterprises (50%) runs quality control at individual stages of production.

The key element in this concept is also to provide the participation of employees in the decision-making process. It is claimed that the managerial staff of the company should introduce such a system so that every employee is actively involved in the team (Dahlgaard et al. 2000). Results of investigations showed that in 33% enterprises belonging to group A employees participate in decisions concerning the operation of the enterprise. It was found that in this respect there is a trend showing that the bigger an enterprise, the more frequently employees participate in making decisions connected with the operation of the entity, the respective figures being 53% in group B and 83% in group C.

Outsourcing
The concept of Outsourcing is based on the assumption of an enterprise, focusing on these areas of activity in which this enterprise has a competitive advantage. Areas, in which it is impossible to enhance this competitive advantage, are isolated from the processes of its operation and their previous activity is realized by external companies (Bozarth et al. 2007). However, Outsourcing differs from typical commissioning, which is common practice in the operation of enterprises. The main difference consists in the focus on primary activity and means that a permanent and constant partnership cooperation is found between enterprises, in which one declares to buy from the other partner their products or

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services, which had been previously produced in their own enterprise - it is the so-called *contract outsourcing*. The other form of outsourcing is *capital outsourcing*, which consists in the isolation from the enterprise functions together with assets and workers in order to establish a daughter company, or in the capital takeover of another firm, not related in any way with the enterprise. Results of investigations concerning the degree of implementation of outsourcing in agricultural enterprises are presented in Fig. 2.

In group A capital outsourcing was found in one enterprise. In turn, over 50% all entities in this group use external services. They are mainly transport services and extension services, as well as harvesting of green crops, maize or digging beets.

In turn, in group B none of the entities has isolated from their enterprise functions with assets and workers. However, all these economic entities use external services. Four farms use transport services, additionally two of them use warehousing and distribution services, financial and information services, maize ensiling and repair services.
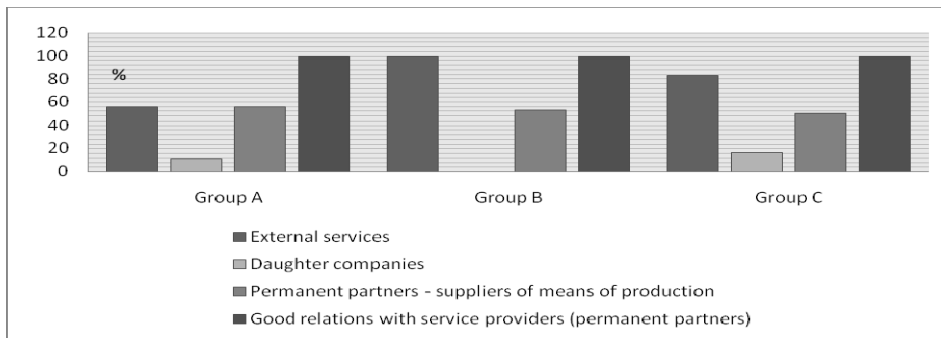
Figure 2. The degree of implementation of outsourcing
Source: the authors' study

In group C, composed of the biggest enterprises, two of them gave positive answers to the question concerning daughter companies. It needs to be stressed that 83% enterprises use external services. In turn, as far as the type of services is concerned, these units to a slight extent use veterinary services, extension

services and mechanization services. It is a result of a high degree of mechanization of works, both quantitatively and qualitatively, having highly qualified employees, e.g. some veterinary works are performed by the enterprise's workforce.

The concept of outsourcing also means the establishment of long-term and permanent partnership cooperation between firms, where one of them declares to purchase from the partner not only services, but also products, which had been previously manufactured by the firm itself. It results from the responses given in questionnaires that in each of the analyzed groups of enterprises approx. 50% investigated population have contracts with suppliers of goods. All subjects have good relations with suppliers of goods, with whom they have signed agreements.

Discussion and Conclusions

With Poland's accession to the European Union the domestic market in Poland was subjected to the rules governing EU markets, at the same time becoming the international market of global competition. Competition on world markets enforced changes concerning concepts for and the realization of new structures not only in the enterprise itself, but also in its environment. In the opinion of Ciesielski (2001), chances to gain competitive edge are associated in 20% with automation, while in as many as 40% in novel management methods (including logistics management). Interest in the Polish market expressed by foreign investors, an increase in the requirements faced by Polish food producers in terms of e.g. punctuality, quality, reliability of deliveries, efficient stock management or division of labour, as well as increasing competition in domestic and international trade all force agricultural enterprises to improve their logistic efficiency. Modern improvement of organization and management in agricultural enterprises, thanks to the introduction of elements of logistics, has been progressing gradually. It needs to be stressed that a slight degree, to which tools of the discussed logistics management concepts have been implemented, results mainly from the specific character of agricultural production, which differs from others not only in the type of the products, but first of all in the conditions

and methods of production. Agricultural production is run in an uncontrollable natural environment, exposed to the continuous action of natural factors, which remain outside the scope of human impact. The spatial character of plant production results in the need of mobility of machines and tools, as well as an increased demand for means of transport. It also causes additional difficulties connected with the control of production processes. In turn, cyclicity of the production process results in a varied demand for labour and hinders an efficient utilization of workforce and tools in an enterprise (Wielicki et al., 2002). This fact should convince enterprises to introduce outsourcing, taking into consideration the above-mentioned principles.

The widest range in the modification of quality is obtained at present within Total Quality Management (TQM), where quality constitutes an integral element of policy of an enterprise (Blaik, 2001). In this concept all actions, starting from product development through design up to the moment of customer service, have become the subject of quality modification. The enterprise should constantly identify customer needs in terms of products, services and sales promotion, since winning customer trust for the company is the best sign of quality (Urbaniak, 2004). In conclusion, in relation to TQM we found that some of the elements of this concept, such as training or the control of means of production, are implemented in all enterprises to a considerable degree. Documenting quality in the form of certificates, quality certificates or laboratory measurements were especially found in the large companies (group C). A rather serious problem in most enterprises was connected with a lack of responsibility and a lack of initiative on the part of operatives, as well as the fact that consumer satisfaction was hardly ever monitored.

In relation to outsourcing, in the analyzed enterprises neither capital outsourcing (only 3 enterprises distinguished its assets with functions and employees) nor contract outsourcing are common (although in the later case already 7 enterprises reported such actions). It results from the fact that the process of implementing this concept is very complex and depends on many factors, such as the size of the enterprise, the line of business as well as areas which are to be isolated from the firm.

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THE SCOPE OF IMPLEMENTATION OF MODERN MANAGEMENT CONCEPTS IN AGRICULTURAL ENTERPRISES IN POLAND
Part 2 – REENGINEERING, CIM, ECR

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Keywords: logistics management, Reengineering, CIM, ECR, agricultural enterprise

Abstract

The paper is a continuation of an analysis concerning an assessment of the implementation of modern management concepts in agricultural enterprises presented in part 1. This part referred to issues connected e.g. with such concepts as Reengineering, CIM and ECR. In this respect the investigations showed that surveyed enterprises apply neither electronic data exchange nor bar codes. Electronic data exchange in those enterprises is maintained in the traditional form. Computer subsystems are still a novelty and are used to a limited extent, mainly due to a lack of specialist software adapted to the specific character of agricultural enterprises, but also because these enterprises are not sufficiently equipped in hardware.

Introduction

How it was recalled in the part 1 of the paper, in recent years the increasing complexity of problems connected with the operation of an enterprise turned out to be so high that it has resulted in the development of many novel management concepts. Some of them are complementary to logistics, which might or should be adequately used to achieve and maintain a specific position of an enterprise on

the market. However, it needs to be remembered that an adequate determination of relationships between logistics and other concepts is required for it to function appropriately. A proper execution of such a task has to be incorporated in the management of the enterprise as a whole and result from its specific character (Ciesielski, 2006). Other concepts, not presented in part 1, most closely related to logistics include first of all Reengineering, Computer Integrated Manufacturing (CIM), Efficient Consumer Response (ECR)
(Christopher, 2000, Ciesielski, 2006, Gołembska, 2007, Witkowski, 2002, Wojciechowski, 2007). Thus the objective of the study was to assess the degree of implementation of the above-mentioned management concepts in agricultural enterprises.

Material and methods

The methodological design of the survey questionnaire was the same like presented in the part 1. A questionnaire, including sets of questions identifying individual management concepts, was sent to all of the 60 selected enterprises with a minimum of 500 ha utilized agricultural land (UAA) in the Wielkopolska region.

In turn, information concerning a radical change in the organization of labour in the history of an enterprise, radical transformations of entire processes in order to improve efficiency, changes in the kind of production as well as data concerning conducted workshops with the participation of specialists will facilitate an assessment of the degree to which the concept of Reengineering has been implemented.

The aspiration to integrate computer processing of economic and technical tasks, meeting increased requirements of customers, constitute major elements of CIM. Information on the application by agricultural enterprises of computer subsystems for computation and simulation, production planning and control, data acquisition, transport control as well as the existence of information flows between enterprises will be useful in the assessment of the degree, to which this concept has been implemented.

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Similarly as in case of CIM, information flow plays a considerable part in ECR. A common data base in the system of two primary processes, i.e. manufacturing of products and the execution of orders, and monitoring of customer satisfaction will indicate whether a given enterprise uses elements of Efficient Consumer Response.

Research Results

In relation to the reengineering concept, the question whether in the history of an enterprise there has been a thorough transformation of comprehensive processes, connected e.g. with a change in the kind of production in order to improve efficiency was answered positively in each group of enterprises by over 50% respondents. As far as a radical change in the organization of labour is concerned, most enterprises and in group C all of them confirmed this fact (Fig.1).
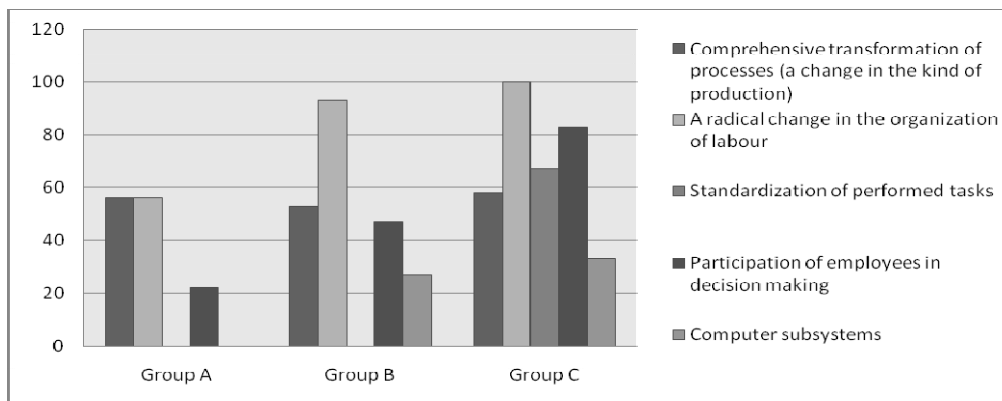
Figure 1. The degree of implementation of Reengineering
Source: the authors' study

In this concept different stages of processes, which had been previously realized by workers at different departments, are now performed by one individual taking over the entire responsibility for the process. In enterprises of 500 – 1 000 ha and of 1 001 - 2 000 ha standardization of task performance by operatives has not been reported. The situation is different in case of enterprises of more than 2 000 ha UAA, where in 67% farms standardization of performed

tasks occurs, which contributes to the concentration of responsibility and the elimination of the need to delegate work to other people. Reengineering leads not only to horizontal, but also vertical condensation, which means that these competences are delegated to workers, which had previously been reserved only for managers. It results from data coming from questionnaires that in the group of enterprises with the smallest area workers in 22% cases participate in making decisions concerning the activity of the enterprise, while in farms of 1 001 - 2 000 ha it is so in 47% cases, and in economic entities of over 2 000 ha they participate in this process in 83% enterprises. Talking about Reengineering we may not neglect information technology as a crucial factor supporting this concept. Economic activity using a PC, telephone, fax and the Internet, especially when we deal with such radical changes as in case of Reengineering, is a necessity (Krupski, 1999). However, results of these investigations indicate that in 75% enterprises in group A there is no integration or modification of information flows. In turn, in group B all enterprises use the telephone as a technical means in information flow, for 75% enterprises this tool is a fax and in 25% - the Internet. In group C in all enterprises some integration of information flows is observed, in 27% it is executed through the Internet, in 100% using the phone and in 33% by paper documents. The integration of information flows is conducted least often using computer subsystems. Enterprises in group A do not apply it at all. As it may be seen in Fig. 1, computer subsystems are used in 27% enterprises in group B and 33% in group C.

CIM – Computer Integrated Management
The assumption in this concept is to treat the entire process as a series of data processing operations, which need to be interrelated through respective information and communication systems. As a result of these investigations it was found that in the group of enterprises A such systems were not used. In turn, in groups B and C such systems were observed in 27% and 33% all enterprises, respectively (Fig. 2).
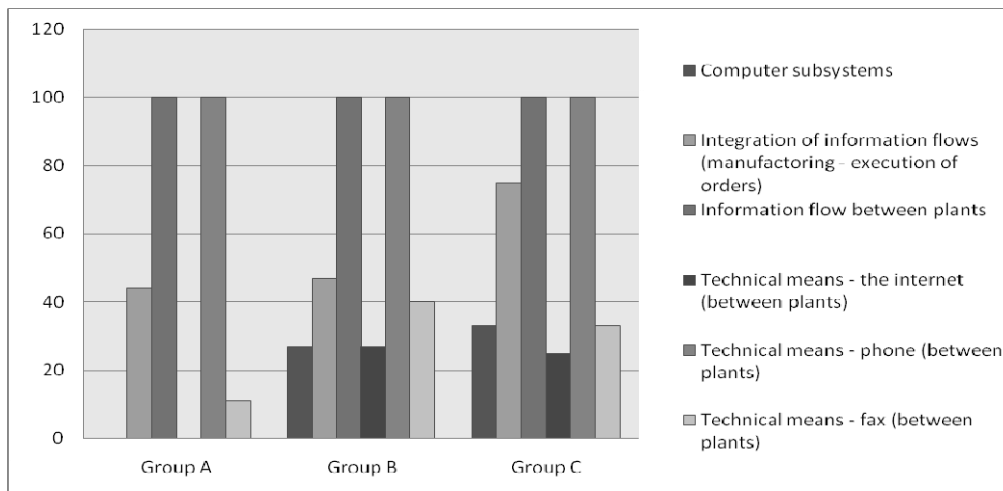
Figure 2. The degree of implementation of CIM
Source: the authors' study

These enterprises mentioned such subsystems as the system of cost controlling, agricultural calculations and management of cow herds. They were subsystems developed for typical agricultural enterprises. Apart from these subsystems, there were specialized ones, such as the Computer Aided Engineering (CAE), Computer Aided Planning (CAP), Computer Aided Quality Assurance (CAQ) and Production Data Acquisition (PDA) subsystems.

In the CIM concept information flows are integrated in the technical sense in the system of two basic processes: manufacturing and the execution of orders. In individual groups a common data base in the system of these basic processes was found in 44% enterprises in group A and 47% enterprises in group B, while it was 75% in group C.

Another aspect of computer aided management is the integration and modification of information flows within an enterprise between its individual plants. In surveyed enterprises information flow is executed using such means as the telephone (100% enterprises in all groups), fax (11% enterprises in group A, 40% in group B and 33% in group C) and the Internet (not found in group A, 27% enterprises in group B and 25% in group C). Figure 5 presents technical means and the type of information exchanged using these means. Obviously,

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apart from information sent via these means, traditional paper documentation is exchanged as well.

ECR – Efficient Consumer Response

Cooperation within this concept is understood as a far-reaching partnership, both within one's own enterprise, and between entities in the supply chain. As far as procurement is concerned, analyzed enterprises have signed contracts for permanent supplies with approx. 50% suppliers (Fig. 3). Relations with those suppliers were defined as good or very good.
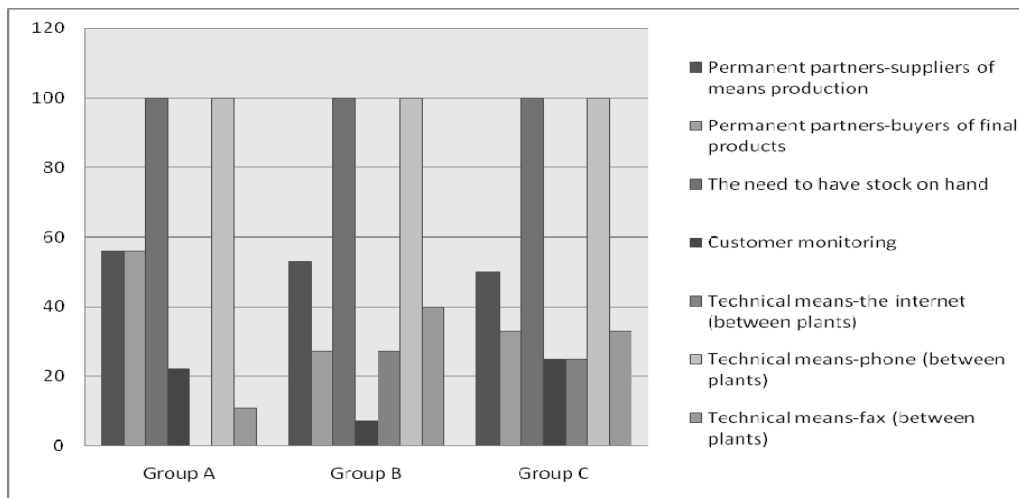
Figure 3. The degree of implementation of ECR
Source: the authors' study

In turn, the biggest number of contracts are signed with suppliers of finished products by enterprises from group A (56%), whereas in enterprises belonging to groups B and C it is approx. 30%.

An essential element in ECR is to adopt a specific re-supply strategy. In this respect we may distinguish two strategies, one being just-in-time deliveries (JIT), reducing stock costs to the minimum. In analyzed enterprises this pertains first of all to plant protection agents, seeding material or spare parts to machines.

Another strategy observed in analyzed enterprises is to have supplies delivered in advance, long before they are used in the production process. This pertains to such means of production as mineral fertilizers, where at purchase enterprises are granted profitable rebates, exceeding in value the costs of incurred stocks. Thus, under such conditions stocks on hand are found in analyzed enterprises and these enterprises do not see the need to eliminate them.

As in the previous concepts, the customer is the starting point and target of the joint actions of partners. Thus it is crucial to monitor customer satisfaction. In analyzed enterprises it is generally a novelty and for this reason only a small percentage of enterprises uses this element (from 7% in group B to 25% in group C).

Discussion and Conclusions

Reengineering is a method of a thorough transformation of comprehensive processes in an enterprise in order to optimize basic indicators of efficiency, such as cost, date of completion, quality or customer service, thanks to the application and use of modern know-how and methods of economics, information technology and psychology. A combined action of these indicators as a consequence brings a synergic effect (Bozarth and Handfield, 2007). Summing up this issue, tools of this concept are least apparent in the group of enterprises with the smallest area. Comprehensive transformation of processes was found in 50% agricultural enterprises in each group. A radical change in the organization of labour took place in each group of enterprises. Computer subsystems are scarcely ever used.

As we may see from Fig. 3, the participation of employees, having an influence on the operation of their enterprise, increases with the size of this enterprise in terms of UAA.

The use of electronic data processing technologies leads to the integration of organizational and technical data, connected both with the preparation and execution of production. Increasing requirements of the market, the necessity to replace long-run production with customized one and individualization of

demand, changes in procurement, production and sales, have all contributed to the development of the concept of *Computer Integrated Management* (CIM) (Kempny, 2001). In conclusion, computer subsystems are still a novelty and they are used to a very limited extent, mainly due to a lack of specialist software adapted to the specific character of an agricultural enterprise, and secondly as a consequence of these enterprises being insufficiently equipped with hardware. For example, internal computer networks linking individual plants were not found in any of the analyzed enterprises.

The concept of *Efficient Consumer Response* consists in the joint development of strategies and courses of action by all participants in the supply chain in order to reduce stocks on hand and costs, and respond promptly to the changing needs of customers. These goals will be realized thanks to the close and efficient cooperation of the partners in the logistics chain and the application of information technologies (Coyle et al., 2002). ECR requires the application of modern information technologies by all components of the supply chain, facilitating efficient acquisition, processing and sharing of information in the supply chain. However, the primary task for information technologies is to overcome barriers in contacts between both entire enterprises and functional departments. The basic pre-condition for the implementation of ECR is to apply electronic data exchange, electronic money transfers, automatic identification based on the bar code system and data management. ECR calls for the possible elimination or at least considerable limitation of paper document circulation when realizing this concept (Witkowski, 2003). Analyzed enterprises do not apply electronic data exchange or bar codes. Electronic data exchange in these enterprises is executed in the traditional way due to the previously mentioned lack of an adequate IT infrastructure. However, it needs to be stressed that there is an Animal Identification and Register System, which makes it possible not only to follow the history of animals, but also to support the Veterinary Inspection service.

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ASSESSMENT OF CEREALS AND MAIZE AGROPHAGES (PESTS AND DISEASES) IN DIFFERENT REGIONS OF POLAND

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Keywords: cereal and maize pests and diseases, harmfulness assessment

Abstract

In Poland the harmfulness and occurrence of the agrophages have been monitored from 1950 onward. This information is the base of the evaluation of the tendency of pests and diseases spread as well as their economic value affected among other factors by climate changes.

Introduction

In the growing season 2006/2007 meteorological conditions in Poland were favourable for cereals and maize development. At spring 2007 sowings started two weeks earlier than normally. Unfortunately, the lack of rain in April/May was unsuitable for cereals, mainly for spring cereals. Rainy and cold weather in May/June improved the soil humidity, but those humid conditions were favourable for fungi diseases development. In Poland cereals still cover the largest agricultural area. In 2007 8,4 million ha were used for cereals and this area was a bit smaller than in previous years. Received cereals production in 2007 was 5.4 million tons higher than the yield in 2006 and 0.4 million ton more than the 2001-2005 average. One of the factors influencing the production height and quality is agrophages (pests and diseases) occurrence. Monitoring is one of the most important sources of information on pests/diseases harmfulness assessment.

Materials and Methods

System of monitoring comprises of field observation which takes place once a year in a specific period of time, separately for every pest or disease according to uniform methods (*Pruszyński et al.1993, Walczak et al. 1998, Węgorek et al. 1976, 1982*). Monitoring must be objective and should give the possibility to compare pest or disease harmfulness in different regions of Poland. Observations are provided by the Plant Health and Food Security Inspection Service and then sent to the Plant Protection Institute where all iof the nformation is worked out and published at the end of the year (*Walczak et al. 2006*).

Cereals and maize agrophages harmfulness is expressed as the percentage of infected or damaged stems, ears, leaves or whole plants depending on pest/disease. Every year the list of important pests and diseases which must be monitored is updated.

Research Results

In 2007 monitored cereals and maize diseases and pests consisted of : powdery mildew (*Blumeria graminis*), brown rust (*Puccinia recondita*), septoria leaf spot (*Septoria nodorum*), take all diseases (*Molisia yallundae* and *Gaumannomyces graminis*), cereal leaf beetle (*Oulema* spp.), bird-cherry aphid (*Rhopalosiphum padi*), cereal aphid (*Sitobion avenae*), saddle gall-midge (*Haplodisplosis equestris*), frit fly (*Oscinella frit*) and European corn borer (*Ostrinia nubilalis*)— Maps 1-11 and Graphs 1-11.

In 2007 powdery mildew was observed commonly in Poland. In comparison to the growing season 2006 a decrease of disease intensity (in 2006 22.3% of infected winter wheat plants – average for Poland) was registered. In Northern parts of Poland (pomorskie, warmińsko-mazurskie, zachodniopomorskie) the highest disease harmfulness was observed - map 1, graph 1.

In 2007 the brown rust caused by fungi *Puccinia recondita* was observed commonly in Poland too. In comparison to the growing season 2006 an increase

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of disease intensity (in 2006 8.3% of infected winter wheat plants, in 2007 – 9.8%) was registered. Similarly to last few years mainly in the Southern and South- Eastern parts of Poland the highest disease harmfulness was observed - map 2, graph 2.

Septoria leaf spot was observed commonly in Poland. After four years of diseases incidence decrease, in 2007 an increase was registered (8,4% of infected winter wheat ears). The highest disease harmfulness was observed in Northern and Southern parts of Poland - map 3 , graph 3.

Take all diseases (*Ramulispora herpotrichoides* and *Gaumannomyces graminis*) in 2007 were observed commonly in Poland but in small incidence (4.2% and 3.3% of infected winter wheat stalks) – maps 4-5, graphs 4-5. Higher *Ramulispora herpotrichoides* incidence (higher than many years average – 12.7%) was noticed in opolskie, pomorskie and lubelskie regions.

Winter wheat pests which were monitored in 2007 (cereal leaf beetle, bird-cherry aphid, cereal aphid and saddle gall-midge) were observed commonly in Poland (except saddle gall-midge – its occurrence is strictly connected with specific soil conditions) at different levels of pests occurrence – maps 6-9, graphs 6-9.

Maize pests like frit fly and European corn borer are monitored since last few years as the result of the significant increase of maize area in Poland – maps 10-11, graphs 10-11.

Map1	Graph 1
Powdery mildew - Blumeria graminis DC. % of infected winter wheat stalks in 2007	Average % of infected winter wheat stalks by powdery mildew - Blumeria graminis DC. in Poland in 1991-2007

Map2	Graph 2
Brown rust - Puccinia recondita Rob. ex Desm. f.sp. tritici (Erikss.) C.O. Johnson - % of infected winter wheat stalks in 2007	Average % of infected stalks by brown rust - Puccinia recondita Rob. ex. Desm. f.sp. tritici (Erikss) C.O. Johnson in 1991-2007

Map3	Graph 3

Map4	Graph 4

Map 5	Graph 5

Map 6	Graph 6

Map 7	Graph 7

Map 8	Graph 8

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Map 9	Graph 9
Saddle gall midge - Haplodiplosis equestris Wagner percentage of winter wheat damaged stalks in 2007	Average % of damaged stalks by saddle gall midge - Haplodiplosis equestris Wagn. in Poland in 1991-2007
Map 10	Graph 10
Frit fly - Oscinella frit L. and Oscinella puzilla Meig. % of damaged corn plants in 2007	Average % of damaged corn plants by frit fly - Oscinella frit L. and Oscinella puzilla Meig. in Poland in 1991-2007

Map 11	Graph 11
European corn borer - Ostrinia nubilalis Hbn. % of damaged corn plants in 2007	

Conclusions

1. In 2007, in comparison to 2006, an increase of brown rust, septoria leaf spot and take all diseases occurrence was observed.

2. Within the last few years the diseases infecting cereals have particularly increased.

3. In Poland observation of economic significant agrophages enables to assess the health conditions of the agricultural plants and also to determine the changes in the quantity of particular agrophage species.

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LEVEL OF ADAPTATION OF FAMILY AGRICULTURAL HOLDINGS TO EU STANDARDS

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Keywords: EU standards, agricultural holdings, adaptation

Abstract

The aim of the study was to analyse the problem of adapting family agricultural holdings in Poland to the standards of the European Union concerning: production hygiene, livestock welfare (conditions in which animals are kept) and the protection of the environment. The research was based on support programmes for family agricultural holdings, which in order to receive subsidies must adapt to EU standards. The number of family agricultural holdings in Poland of over 1 ha of arable land was 1,786,000 in 2005, out of which 1,450,000 apply for subsidies for agricultural land. Based on the participation in programmes, it has been found that in years 2002-2007 there were/are 320,724 family agricultural holdings, which constitutes 17.9% of all agricultural holdings of areas over 1 ha of agricultural land and over 22% of all agricultural producers who receive subsidies for agricultural land. Most agricultural holdings adapted to EU standards in years 2002-2007 can be found in the voivodeships of Eastern and central Poland while the largest percentage in relation to the total number of holdings is found in Western, Northern and central Poland.

Introduction

As a result of economic transformations which took place in Poland at the beginning of the 1990s, agriculture has become a barely profitable branch of the economy (MRiRW, 2007). The agrarian structure of Polish agriculture is dominated by small holdings. A small scale of production also limits the possibilities to realise technological progress, both for financial and technical reasons (MRiRW, ARiMR 2006). In mid-2003 only about 16,000 holdings (4% of 400,000 holdings) supplying milk to dairy plants satisfied the requirements for milk quality that were in force in EU (MRiRW, 2004).

The aim of the study was to analyse the problem of adapting family agricultural holdings in Poland to the standards of the European Union concerning: production hygiene, livestock welfare (conditions in which animals are kept) and the protection of the environment.

Material and Methods

The present study assessed the adaptation of Polish agriculture to EU standards in years 2002-2007 on the basis of statistics from the Agency for Restructuring and Modernisation of Agriculture.

Discussion and Conclusions

The number of family agricultural holdings in Poland of an area of arable land over 1ha in 2005 was 1,786,700, of which about 1,4500,000 have applied for subsidies for agricultural land (Table1). It can be assumed that they are active holdings that are interested in adapting to EU standards as they run agricultural holdings in a documented form. In years 2002-2006, 56,326 family agricultural holdings took part in the 'Investment in Agricultural Holdings" programme (Droździel, 2007). A total of 75,907 holdings got subsidies through the 'Adapting agricultural holdings to EU standards' programme. The results of the study show that this programme was the most popular with farmers (MRiRW, ARiMR 2007). The programme 'Setting-up of young farmers' was aimed at

holdings that wanted to improve their economic standing, adapt production for the market, improve the quality and technology of production as well as to adapt for sanitary and veterinary standards of the EU. A total of 18,857 holdings were subsidised. Within the 'Modernisation of Agricultural Holdings' programme, in 2007 farmers made 18,334 applications.

An estimated 151,350 holdings will adapt to EU standards as part of the 'Supporting Low-Produce Holdings' programme. The programme is to financially support small holdings to increase their investment potential. On the basis of participation in the programmes, it has been found that in years 2002-2007 320,724 family holdings were/had been in the process of adaptation to EU standards, which constitutes 17.9% of all agricultural holdings of areas over 1ha. It also constitutes over 22% of agricultural producers who receive subsidies for agricultural land.

Table 1: Number of agricultural holdings in Poland adapted to EU standards in years 2002-2007

Voivodship	Holdings applying for support in 2007	Holdings adapted to EU standards		2002-2006 2004-2006				2007
		number	%	IGR[1]	MR[2]	DSU[3]	WGN[4](*)	MGR[5]
Dolnośląskie	61,026	6,839	11.2	1,862	839	689	2,900	549
Kuj.-Pomorskie	68,685	26,705	38.9	4,826	1,458	13,085	6,000	1,336
Lubelskie	184,370	40,386	21.9	6,057	2,087	3,177	27,100	1,965
Lubuskie	21,213	3,242	15.3	857	307	592	1,000	486
Łódzkie	131,935	33,599	25.5	5,023	1,774	6,240	19,000	1,562
Małopolskie	138,318	19,516	14.1	2,813	723	1,235	14,000	745
Mazowieckie	219,958	56,559	25.7	10,000	3,040	15,774	25,000	2,745
Opolskie	29,317	4,525	15.4	1,328	531	628	1,600	438
Podkarpackie	128,225	13,394	10.4	1,404	525	950	10,000	515
Podlaskie	83,779	19,547	23.3	3,533	1,516	5,970	7,000	1,528
Pomorskie	39,991	11,554	28.9	2,479	774	4,556	3,000	745
Śląskie	54,580	4,742	8.7	1,212	424	788	2,000	318
Świętokrzyskie	94,957	27,429	28.9	3,928	747	1,648	20,000	1,106
Warm.-Mazurskie	43,867	10,419	23.8	2,130	962	4,530	2,000	797
Wielkopolskie	124,361	36,510	29.4	7,397	2,564	14,762	9,000	2,787
Zachodniopomorskie	29,681	5,758	19.4	1,477	586	1,283	1,700	712
Total	1,454,263	320,724	22,0	56,326	18,857	75,907	151,300	18,334

1-Investmets in agricultural holdings, 2-Setting-up of young farmers, 3-Adjustment of agricultural holdings to the European Union standards, 4-Support for low capacity agricultural holdings, 5-Modernisation of agricultural holdings, *-estimated holdings adapted to EU standards.

The largest number of holdings being adapted can be found in Mazowieckie and Lubelskie voivodeships, and the smallest in Lubuskie and Śląskie voivodeships (Table 1). A large number of agricultural holdings (from 39 to 93%) already at the time of application for subsidies for the realisation of projects fully satisfied the applicability requirements concerning production hygiene, livestock welfare and the protection of the environment (Table 2).

Table 2: Structure of holdings according to the satisfaction of standards (%)

Specification	Production hygiene		Livestock livelihood		Protection of the environment	
	IGR[1]	MR[2]	IGR[1]	MR[2]	IGR[1]	MR[2]
Fully satisfied at the moment of application for support	93,6	58,9	82,8	39	71,1	50,5
Satisfied at the basic level at the moment of application for support	3,4	-	4,8	-	4,4	-
Will be fully satisfied after the realisation of the programme	3,0	41,1	12,4	61	24,5	49,5

1-Investmets in agricultural holdings, 2-Setting-up of young farmers.

Conclusions

1. The study showed that the largest number of agricultural holdings adapted for EU standards in years 2002-2007 is in the voivodships of Eastern and central Poland, while the largest percentage in relation to the total number of holdings can be found in Western, Northern and central Poland.
2. It is believed that the low level of adaptation of Polish agricultural holdings to the EU standards (17.9 %) is due to considerable fragmentation of the agricultural sector, weak economic condition and a low level of ecological awareness.
3. The results of the study show that agricultural holdings have a serious problem with adapting to the EU standards concerning the conditions in which animals are kept.
4. It has turned out that first we should try to introduce instruments aimed to financially support agricultural holdings as such activities are highly motivating and stimulating.

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ENERGY

PERSPECTIVE AND PRODUCTION COSTS OF LIQUID BIOFUELS IN POLAND

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Keywords: biofuels, crop production, profitability

Abstract

The biofuels market in Poland shows the current developments and market potential of biofuels. The article focuses on market trends and economic efficiency of small scale biodiesel production. The perspectives of biofuels production with special regard to raw material resources and low regulations in Poland has been presented.

Introduction

The value of the World biofuels market is estimated to be 20 billion US dollars and still grows (Ljungblom 2002). Kioto Protocol on energy safety and decisions confirms that the development of the renewable sources of energy is inevitable; that includes also liquid biofuels. Biodiesel plays the most essential part among liquid biofuels in European Union (above 80% of total production). Agricultural condition in Poland have made biodiesel and bioethanol the most produced biofuels of the country. In 2005, the Polish yearly production has been estimated at 200 000 tons, which represents 50% of the production capacity.

Since the adoption of the EU directive aimed at promoting biofuels consumption, the EU has made some progress in fuel ethanol consumption in particular in Germany, France, Sweden, Spain, the UK and Poland.

The break down in production and utilization of biodiesel in Poland in 2007 happened in the consequence of unfavourable fiscal and legal regulations (Żmuda 2007).

Therefore, Poland does not achieve the value established by the European Committee (Directive 2003/30 / EC) for the coefficient of utilization of biofuels (0.92 % in comparison to the required 2.75 %). That could result in serious financial sanctions.

Materials and Methods

The aim of the study was the analysis of biofuels production in Poland from 2000 to 2007. The perspective of the development of this sector after the year 2008 was also introduced with regard to the competition with agricultural crops for food production. The data-base of Main Statistical Office, European Union Reports, Ministry of Agriculture and Rural Development and Canola Producer Association has been used to prepare the analysis .

Results

Target usage of biofuels for 2005 was set at 2% and should reach 5.75% by 2010. To date, Poland's compliance with the Directive is inadequate. Bio-components' share of total fuels used in transportation in recent years was as follows: 2004 0.30%, 2005 0.48%, 2006 0.92%. According to the newly adopted Long-term Program for Promotion of Biofuels or Other Renewable Fuels for 2008-2014 prepared by the Ministry of Economy and adopted on July 24, 2007, Poland's usage rates are set as follows: 2007 2.30%, 2008 3.45%, 2009 4.60%, 2010 5.75% Moreover, the Polish government plans to attain the level of 7.55% usage by 2014.

In 2007 Poland produced 106.8 thousand cubics of bioethanol which decreased to 79.4 thousand cubics in 2007 (Table 1). Current bioethanol production is quite limited but some of large – scale projects should be realised in 2009 and 2010.

Table 1: Bioethanol production in Poland

Year	Engine gasoline consumption in thous. cubic	in wchich bioethanol in thous. cubic	% share (volume)
1997	6691	110.6	1.65
1998	6672	99.8	1.5
1999	7770	83.2	1.07
2000	6808	51.4	0.75
2001	6233	66.4	1.07
2002	5645	82.8	1.47
2003	5453	76.2	1.4
2004	5564	48.5	0.87
2005	5151	54.2	1.05
2006	5326	106.8	2.01
2007	5395	79.4	1.47

Source: Ministry of Agriculture and Rural Development

The production of biocomponents during several years seriously increased up to over 127 millions tonnes in 2006. To fulfil EU directive the level of production should be higher.

Table 2: Production and sales of bioethanol in 2005-2006 in thousands tonnes

Specification	Bioethanol		
	Year		Dynamics 2005=100
	2005	2006	
Production	88848	127796	144
Total sales	92356	131266	142
Export	31099	37983	122
National market	61257	93283	152

Source: Ministry of Agriculture and Rural Development

Total production of esters has dropped because of unfavourable fiscal and legal regulations to the level of 71 millions tonnes in 2006 and still decreases (Table 3).

Table 3: Production and sales of Esters in 2005-2006 in thousands tonnes

Specification	Esters		
	Year		Dynamics 2005=100
	2005	2006	
Production	90972	71641	78.8
Total sales	61611	45607	74.0
Export	51674	43068	83.3
National market	9937	2539	25.6

Source: Source: Ministry of Agriculture and Rural Development

According to the data shown in tables 4 and 5 the supply in the case of gasoline and diesel oil since 2008 till 2020 will be stable but bioethanol and esters will be 3-4 times higher in this period.

Table 4: Forecast for biocomponents supply in 2007-2020 years

Specification	Year	2007	2008	2009	2010	2011	2012	2013	2020
	Unit								
Gasoline	thous.ton	3980	3920	3860	3800	3800	3800	3800	3800
Bioethanol	thous.c.m.	194123	286766	376537	463307	499566	535825	572084	805752
Diesel oil	thous.ton	7830	8220	8630	8980	8980	8980	8980	8980
Total esters	thous.c.m.	226	356	498	648	699	749	800	1127
Esters - transport	thous.c.m.	139	209	279	349	376	403	430	607

Source: Ministry of Agriculture and Rural Development

Table 5: Forecast for agricultural crops supply in 2007-2020 years for biocomponents purposes

Specification	Unit	Year							
		2007	2008	2009	2010	2011	2012	2013	2020
Cereals	thous.ton	3980	3920	3860	3800	3800	3800	3800	3800
% share on cereals market	x	1.66	2.46	3.23	3.97	4.28	4.59	4.9	6.91
Esters for diesel oil	thous.c.m.	139	209	279	349	376	403	430	607
Canola	thous.ton	293	439	586	732	790	847	905	1274
% share on canola market	thous.c.m.	17.25	25.87	34.49	43.12	46.49	49.87	53.24	74.98

Source: Ministry of Agriculture and Rural Development

On the basis of statistical office data the forecast for potential possibilities of canola production for food and biofuel purposes has been shown in table 6. The level of consumption has been established on 850 thousand tonnes yearly. The amount for biodiesel purposes will raise from 470 thousand tonnes in first period up to 2750 thousands tonnes in third period.

Table 6: Forecast for national canola production

Specification	Realization of program		
	up to 2009	2009-2011	2011-2015
Total area (thous. ha)	550-650	750-850	1000-1200
Yield (t/ha)	2.4-2.6	2.6-2.8	2.8-3.0
Crop (thous.tonnes)	1320-1690	1950-2380	2800-3600
Consumption (thous. tonnes)	850	850	850
Possible amount for biodiesel purposes (thous. tonnes)	470-840	1100-1530	1950-2750

Source: Ministry of Agriculture and Rural Development, Main Statistical Office

In tables 7 and 8 the production of small-scale biorafinery for polish farm condition has been presented.

Table 7: Production costs of biodiesel (84.5 tonnes of fuel)

Production costs				
Specification	Unit	Amount	Price [PLN]	Costs [PLN]
Seeds	t	300	1100	330000
Oil presse	t	300	200	60000
Methanol	l	13100	1.2	15720
Catalyzer	kg	1521	3.3	5019.3
Total				410739.3

Source: Calculation on the basis of Institute of Agricultural Machines (Wysocki 2007)

Table 8: Production sales of biodiesel (84.5 tonnes of fuel)

Sales of by-products				
Specification	Unit	Amount	Price [PLN]	Costs [PLN]
Animal feed	t	230	650	149500
Glycerine	c. metre	29.8	1000	29800
Total				179300

Source: Calculation on the basis of Institute of Agricultural Machines (Wysocki 2007)

The calculation confirmed that minimum price of 1 liter farm made biodiesel was equal to 2.86 PLN in the variant with sales of by-products and price of 1 liter without glycerin sales was equal to 3.22 PLN. At actual fuel market situation and level of duty on diesel (1048 PLN/cubic meter) and tax exemption for biodiesel blends (1.048 PLN) and other custom regulation makes this production non-profitable.

Conclusions

The study confirmed the importance of National Strategy established by Cabinet in the light of EU membership obligations. Polish agricultural land resources and raw material resources show country's huge potential for biofuels production. Competition for food products could be a serious barrier for fuels production in the case of expected food crisis. The strategy of biofuels production in Poland will be determined also by World market oil prices. Small scale of biodiesel production at the level of farm is not actual profitable. There is a need for new low regulations and measurements for biofuels development. It must be implemented as soon as possible to avoid millions euro penalties.

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ENERGY CONSUMPTION RELATED TO THE VENTILATION IN CEREAL STORAGE

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Keywords : cereals storage, cooling, energy consumption

Abstract

Storage of cereals should be done in optimal conditions in order to keep the grains quality. Moreover, since the cereals margin decrease, the storage should be as economic as possible. One of the main aspect of cereals storage is the cooling ventilation. The cooling below 5°C stops the germination and the development of pests and diseases. In Belgium the cooling is done by ventilating the cereals with outside fresh air during the night or frosty days.

This study aims to compare the two main storage facilities (ACMB and silo box) in order to determine the most efficient one in terms of energetic efficiency (electricity/energy consumed to decrease the temperature of one ton cereals by one degree). An additional objective is to determine the most efficient fan (axial or centrifugal) and the optimal number of storage cells to be ventilated by the same fan. Finally, the findings should define a cooling protocol helping the decision making and avoiding energy waste. The practical experiments have been done in collaboration with one of the main Walloon Agricultural

Cooperative (Walagri) which stores almost 300 000 tons of cereals yearly on different sites.

Results have shown that silo box has a higher efficiency. Indeed this technical option leads to a consumption of 0,113 kWh/T°C (energy consumed to decrease the temperature of one ton cereals by one degree), while the ACMB silo needs 0,152 kWh/T°C. On the other hand, the use of the same fan to ventilate 4 storage cells of an ACMB silo increases significantly the energetic efficiency of the storage. Finally records made on axial and centrifugal fans have shown consumptions of 0,078 kWh/T°C and 0,180 kWh/T°C, respectively.

Introduction

Storage of cereals should be done in the optimal conditions of temperature and humidity in order to keep the grains quality. Temperature below 5°C and moisture content under 15-16 % stop the germination and the development of pests and diseases.

At the beginning of the storage, the grains have usually a temperature around 25-35°C which is far from the conservation standard. Therefore the cooling ventilation is certainly one of the main aspect of the cereals storage. The cooling process needs 5-6 months when it is done by ventilating the cereals with outside fresh air during the night or frosty days, as in Belgium.

The cooling process is realized in three steps. Just after the harvest and at the beginning of the storage (July-August), the first step decreases the temperature from ± 30°C to 20°C which reduces the grains respiration and avoid natural heating. In autumn (September – November), the second step aims at decreasing the temperature up to 10-12°C which blocks pests and moulds development. The third step staggered over November-January decreases the temperature under 5°C which allows to preserve the grains for a long period having sprout-inhibition and pesticides effects. Two parameters must be taken into account during the all cooling process. First, the thermal gradient between grains and outside air must reach at least 8°C, otherwise the cooling won't be efficient. Second, the grain storage has an important thermal inertia which can lengthen the cooling process.

Figure 1 : Two main storage facilities in Wallonia : ACMB (left) and Silo Box (right)

Two main storage facilities are usually used in Belgium (Figure 1):
- ACMB storage containing rectangular and vertical cells which have an individual capacity from 400 to 1000 tons,
- Silo box storage containing rectangular and horizontal cells which have an individual capacity from 400 to 1500 tons per silo

Two fan types equip the silo : axial and centrifugal fan (Figure 2).
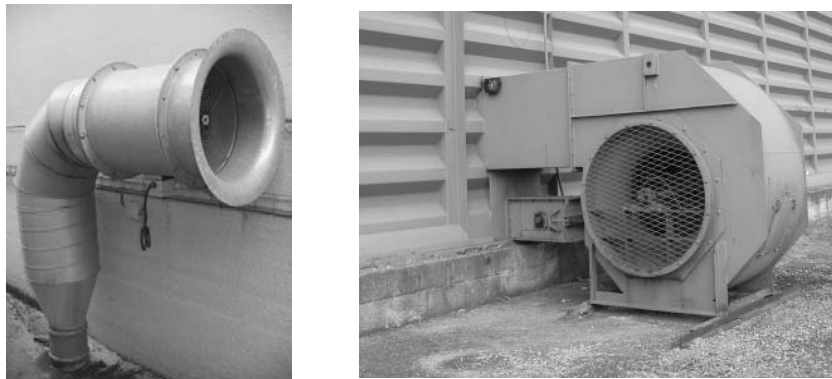

Figure 2 : Ventilation using axial fan (left) or centrifugal fan (right)

Cells of vertical ACMB storage are fed by one centrifugal fan of high power (40 to 50 kW). Horizontal silo box could be equipped with two ventilation system : one axial fan of low power (3 to 4 kW) per cell or one centrifugal fan of middle power (10 to 25 kW) feeding several cells.

Since the cereals margin decrease, the storage should be as economic as possible. The cooling ventilation is electricity consuming and represents a non-negligible budget for the storekeeper. We estimate that $\pm$ 30 – 40 % of the cooling costs (electricity consumption) are not efficient.

The general objective of this study is to reduce the electrical consumption needed for the cooling ventilation of the grain storage.

Specifically, we compare the two main storage facilities (ACMB and silo box), in order to determine the most efficient one in terms of energetic consumption, and we determine the most efficient fan (axial or centrifugal) and the optimal number of storage cells to be ventilated by the same fan.

Materials and Methods

The main parameters of the study were the temperature of the grains and the electrical consumption of the fans. The temperature was directly measured with temperature gauges buried in silos and connected to a recorder device taking one measure/hour. Several temperature gauges have been installed in each studied cell giving us a good picture of the temperature distribution and evolution in the grains silo.

The calculation of the electrical consumption of the fans is based on the functioning time and the nominal power of the fans.

Finally, mobile weather station measures the temperature of outside air used during the cooling process which allows us to determine the **thermal gradient** between the grains and the ventilation air.

Three factors are studied : storage facilities (ACMB or Silo Box), cells number ventilated by the same fan only for ACMB storage and the fan type (axial of centrifugal) for the Silo Box storage.

Trials were realised on 9 sites of an agricultural cooperative from September 2007 to February 2008 and were repeated three times. Only the second and third steps of the cooling process were studied.

Research Results

Cooling process
First the evolution of the different temperatures (temperatures of the grain at the top and the bottom of the silo, temperatures of the outside and ventilation air) during the trials has been expressed graphically as given in the figure 3. Moreover, the ventilation periods were also transferred in this graph showing the effect of the ventilation on the temperature of grains.
Figure 3 shows a perfect cooling process. Each ventilation period decreases effectively the grains temperature step by step. The storekeeper uses cleverly the cold period (night) presenting a sufficient thermal gradient ($>8°C$) to ventilate the silo and avoids the temperature peaks (day).
We can also observe the temperature difference and the cooling delay between the top and the bottom of the silo. That expresses the thermal inertia of the grains storage which is also illustrated by the temperature stability (13 Dec. to 19 Dec.) whatever is the outside air temperature.
It has to be noticed that the ventilated air temperature is always higher than the outside air one. The fan compression causes an average air warming of 2,5°C ($\sigma = 1,1°C$).
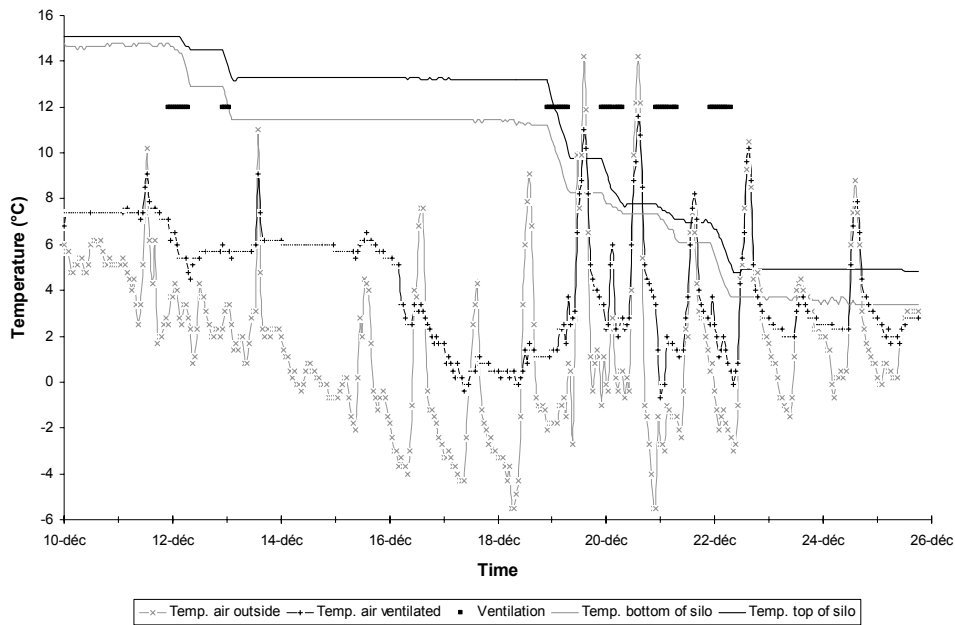
Figure 3 : Graph of the evolution of the different temperatures during the cooling process in an ACMB storage equipped with a centrifugal fan (10/12/07 to 26/12/07)

Cooling processes observed during the trials were not always so efficient. Ill-managed, the ventilation can lead to a re-warming of the grain which translates into energy wastes.

Cooling efficiency
Based on the temperature curves, we determined the efficient ventilation hours (= ventilation hours having really cooled the grain) and compared them to the total ventilation time. On average, the efficient hours reached 47,5% (σ = 16,5%) of the total ventilation time for all trials.

Comparison between storage facilities
The main objective of this study being to establish comparison of the energetic efficacy of the cooling process, we used a specific parameter called the efficient consumption which is the energy consumed to decrease the temperature of one ton cereals by one degree (kWh/t °C). The lower is this parameter the greater

is the cooling efficiency. This parameter allows us to compare, regardless of the silo's size, the fan's power…, the different studied parameters :

- The comparison of the average efficient consumptions for ACMB and Silo Box doesn't show clear difference. On the other hand, their median efficient consumptions are statistically different. Silo Box storages presents a median efficient consumption of 0,113 kWh/t°C and ACMB storage of 0,152 kWh/t°C.

- To increase the number of cells (ACMB storage) ventilated by the same fan can improve a bit the cooling efficiency. Four cells ventilated simultaneously present a median efficient consumptions of 0,145 kWh/t°C whereas two cells needs 0,154 kWh/t°C.

- Axial fan are clearly more efficient and economical than the centrifugal fan (Silo Box storage). Axial fan present a median efficient consumptions of 0,078 kWh/t°C whereas this reaches 0,180 kWh/t°C for the centrifugal fan.

Discussion and Conclusions

This study shows the great importance of a good management of the cooling process of the grains storages. First of all, the storekeeper must make the decision to ventilate when a sufficient thermal gradient (> 8°C) between the outside air and the grain is reached. Moreover, the storekeeper should take into account the air warming ($\pm$ 2,5°C) due to the fan compression.

There is no well-established correlation between the thermal gradient and the cooling process. That means that the cooling would be not more efficient if the thermal gradient is greater. A thermal gradient greater than 8°C is sufficient in any case.

To analyse the efficiency of the cooling process in terms of energy consumption, a specific parameter has been used : the **efficient consumption** which is the energy consumed to decrease the temperature of one ton cereals by one degree (kWh/t °C).

On average (for the whole trials), the cooling efficient reaches hardly 47,5%. That means that more than 50% of the ventilation hours do not cool the grains. Those hours of ventilation aren't efficient and leads to over-consumption of electricity and useless expends. These low performances are mainly due to a bad management of the ventilation. The storekeeper doesn't take into account the thermal gradient and switch on the ventilation too early in the evening when the air temperature is still to high and switch off the fan to late in the morning when the outside temperature has had time to re-increase. This leads to a re-warming of the grains.

On technical point of view, silo boxes seem to present a better efficiency than ACMB ones. This could be explained by the older technology of the latest.

The fan type is clearly a determining factor of cooling process efficiency. Axial fans present a better consumption efficiency than the centrifugal ones. That can be easily explain by the fact that the centrifugal fans are generally over-sized for the storage.

Now new built storages are silo boxes equipped with axial fans. This design ensures better performances.

For the old storages less performing equipped with centrifugal fans, it is possible to increase the cooling efficiency by increasing the number of cells ventilated simultaneously by the same fan (2, 4 and more).

Acknowledgements

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TRACTOR WORK INPUT IN SELECTED FAMILY FARMS

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Keywords: tractor work, family farms

Abstract

The aim of the investigations was to establish the input of tractors work in selected family farms. The investigations were done in 123 farms of the average UAA of 11.48 ha using the standardized questionnaire. It was established that the annual tractor work input increased with the Utilized Agricultural Area (UAA) of the farms from 2,430 to 83,600 kWh. The smallest values were in small farms with only one tractor, whereas the biggest were for big farms which owned, apart from the tractor, also combine harvester, and which offered harvesting services. The average energy consumption calculated for 1 ha was 12.756 kWh per annum.

Introduction

Technical and technological progress in agriculture is the indirect reason for the continuous increase of the fuel and energy outlay. More energy consuming modern machines are more technically advanced and as a result more efficient but they can be effectively utilized only on big farms. However, in Poland, in 2006 the average Utilized Agricultural Area (UAA) of a farm was still 6.27 ha, and more than 80% of the farms had UAA of less than 10 ha (Rocznik Statystyczny…, 2007). Consequently the level of use of technical resources is very low.

Still, with the current disadvantage land structure and relatively low number of new machines it is impossible to reduce significantly energy and tractor work input. The way forward is to improve the awareness of the farmers with regard to the efficient use of the machines and effective agricultural methods (Lorencowicz and Uziak, 2007).

Research Methodology and Farms Characteristic
Research was performed in 2006 on a group of 123 family farms using a standardized questionnaire which was administered by advisers from the regional Agricultural Extension Centre and later verified. The main aim of the research was to estimate the annual tractor work input (expressed in kilowatts hours) and to relate these parameters to the UAA of the farms. The results were determined both in terms of annual totals for a farm and also in terms of equivalents per unit of area (hectare of UAA). Specially prepared Microsoft Access database (Lorencowicz and Kocira, 2004) was used for handling of the results whereas Microsoft Excel spreadsheet was used for statistical calculations and trends prediction.

The analysis was done on 114 farms as 7 farms (of size below 2 ha and above 50 ha) were removed as they significantly differed from the rest of the group, 2 more questionnaires were not considered as they contained wrong or incomplete information.

The farms were arranged according to the UAA. It was assumed that the number of tractors and combine harvesters affected both, annual fuel consumption and tractor work input.

The average UAA of the farms under investigation was 13.61 ha, and after discarding the extreme values, reduced to 11.48 ha (Table 1).

Table 1: Farm area (ha)

Items	Utilized Agricultural Area in hectares				
	Total	With 1 tractor	With many tractors	Without combine harvester	With combine harvester
Minimum	4,31	4,31	7,55	4,4,31	6,50
Maximum	48,20	20,90	48,20	30,50	48,20
Average	11,48	9,59	16,90	9,78	17,42
Standard Deviation	6,27	3,59	8,44	4,14	8,28

This value was more than double of the average of Lublin province which in 2006 had been estimated at 5.32 [Rocznik Statystyczny, 2007]. Among the analyzed farms the biggest group was of the area 5-10 ha – 47%, next 10-15 ha – 31%, above 20 ha – 10%, 15-20 ha – 9% and up to 5 ha – 3% (inclusive of the lower limits) - Fig. 1.
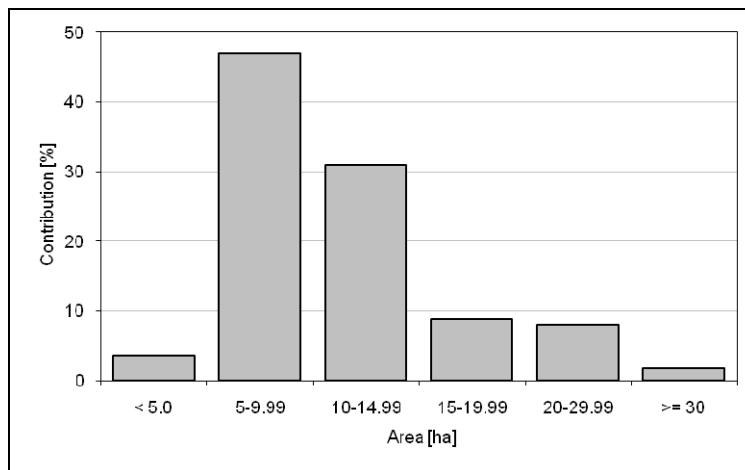
Figure 1: Farm areas structure

The investigated farms had not only different UAA but also other machine equipment. There were 145 tractors and 26 combine harvesters, in total. On average, each farm had tractor power of 35.5 kW, with variations between 18 kW to 98 kW. For the farms with combine harvesters, the available average power increased to ca 160 kW. Almost one third of tractors (31%) had power of 30-40 kW, 15% - below 20kW, 13% - above 60kW, 11% - 50 to 60 kW and 3% - 40 to 50kW (inclusive of the lower limits) - Fig. 2.
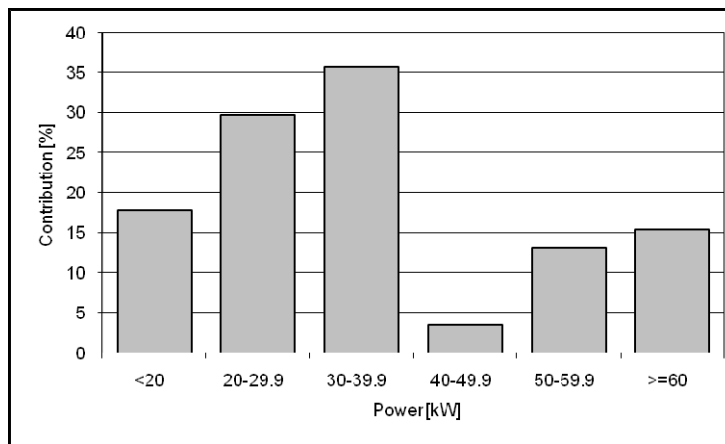
Figure 2: Structure of tractors power in farms

The smallest average area had farms with one tractor (9.59 ha) and the ones without combine harvester (9.78 ha). The farms with more than one tractor had an average area of 16.90 ha whereas farms with combine harvester 17.42 ha.

Results

The average annual tractor work input expressed in kWh was 12,400. The work input was correlated with the UAA of the farms as shown in Fig.3a. In majority of the investigated farms tractors were used only for jobs on its own land. However, twenty farms did also contract work hence the work input increased and varied between 2,430 and 83,600 kWh (Fig. 4a).
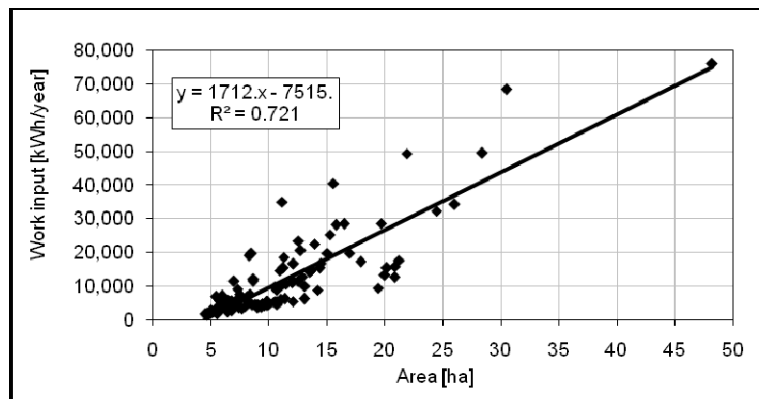
(a)
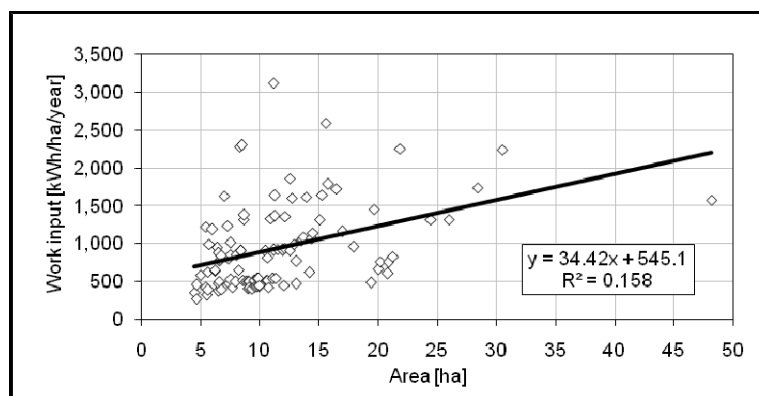
(b)

Figure 3: Annual tractor work input (without contract work): (a) total, (b) expressed per 1 ha

In farms offering contract work the annual average work input was 31,200 kWh (ca 960 kWh per hectare per year) (Fig.4).

The work input expressed per unit of area (ha of UAA) varied between 376 and 3,128 kWh per year (standard deviation 576 kWh/ha). However, it was also different for farms with contract work which had bigger areas (average 21.40 ha, standard deviation – 7.54 ha). In such farms, the internal average work input was at the level of 29,430 kWh (standard deviation 18,210 kWh/year) whereas the work input for contract work was between 380 to 7,600 kWh (average 1,803 kWh, standard deviation – 1,970 kWh/year).
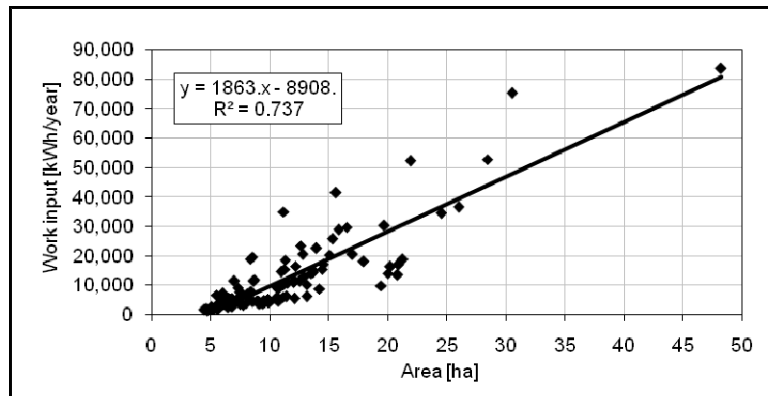
(a)
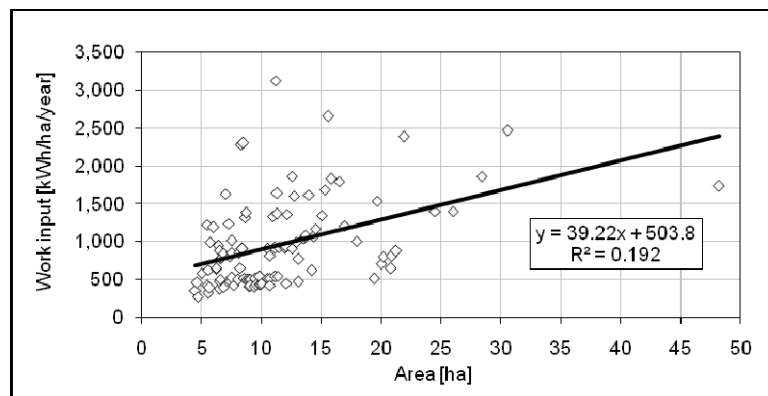
(b)

Figure 4: Annual tractor work input (with contract work: (a) total, (b) expressed per 1 ha

Coefficient of determination between the year input and UAA had a value of 0.72 in all cases, which indicates a relatively high relation between these variables. The correlation between the input expressed per 1 ha and UAA was moderate.

Conclusions

Based on the analysis presented the following conclusions were drawn for the family farms under consideration.

1. Tractor work input, expressed in kWh, depends on the tractor power, the number of work hours, farm area and contract work. It varied between 376 and 3,128 kWh per hectare annually.
2. The farms doing contract work had higher average area than the rest of the investigated farms (21.40 ha with the total average of 11.48 ha of UAA). In such farms the tractor work input was 145% higher than the average of all farms which was 31,323 kWh per year.

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EVALUATION OF POWER CONSUMPTION IN THE PROCESS OF PELLETS PRODUCTION FROM PLANT MIXES

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Keywords: biomass, pellets, condensing, power consumption, plant mixes

Abstract

The paper presents results of research on electrical energy consumption by an engine driving a pelleting working unit during production of pellets from mixes of crushed plant materials. An influence was determined of the percentage of particular raw materials in the prepared mixes on the amount of energy required for their densification. The highest energy consumption per mass unit was recorded for the mix with the largest percentage of wooden sawdust as well as the crushed oat and wheat grain (0.074 kW/kg). The lowest energy consumption was observed for the mix with low sawdust content and an addition of fodder maize remainders crushed after-harvest (0.189 kW/kg).

Introduction

Waste plant materials are not easy for rational exploitation. Their direct use for energetic purposes can be limited or even impossible due to their high moisture level, crushing condition etc. (Hejft, Obiedziński, 2006). Therefore, plant materials exploited for heat energy production are processed by pelleting or briquetting (Hejft, 2002).

Pellets, due to their fine, condensed form, belong to the most universal solid fuels of plant origin considering their storage and transport efficiency as well

as high energetic value (Hejft, 2002). Their small size and regular, cylindrical shape allows for precise, automatic feeding to the furnace as well as an optimization of airing conditions required for their effective combustion (Kowalewski, 2008).

The main raw materials for pellet production in Poland are sawdust and shavings issued from wood industry. However, their amount is limited, so other sources of lignine-cellulose biomass are being considered, e.g. willow, mallow etc. (Stolarski, 2004). Use of plant waste as well as waste materials from agricultural production or wood industry for pellet production is pro-ecological in view of their ecological utilization (Niedziółka et al., 2007).

Pellets are created in a technological process based mainly on drying, crushing and pressing of plant materials in adequate conditions. Due to different physical and chemical properties, raw materials are characterized by varied susceptibility to pelleting. Good susceptibility means lower energy consumption during the pelleting process and improved quality parameters of the pellets (Zawiślak, 2006). Materials for pellet production should be characterized by moisture within the range of 8-15%. Higher moisture of raw materials results in a lower agglomerate quality, especially as to the density and kinetic endurance. Moreover, higher moisture of the material results in drop of its calorific value as well as higher emission of pollutants during combustion (Hejft, Obiedziński, 2006).

Each activity connected with the preparation of material for pellet production involves consumption of energy used by devices applied in this technological process. This paper is an attempt to present results of research on energy consumption during production of pellets from the prepared mixes of crushed plant materials.

Materials and Methods

Pellets were produced from plant waste material such as: defective oat and wheat grain, waste from fodder maize drying (glumelles), straw and fodder

maize cores, sawdust as well as used plant oil (Tab. 1). These materials were crushed by means of a crusher H 111/4, equipped with a hammer crushing unit and sieves of 3mm holes diameter. They were then mixed in different proportions. The total sample mass was 10 kg.

For the condensation of the biomass the RMP 250 type pelleting device was used equipped with the condensing unit made of ring matrix with hole diameter of 3.5 mm and working width 45 mm as well as two condensing rollers with the diameter of 95 mm and width of 45 mm. Energy consumption was determined during the process of pellet production from the prepared   mixes of crushed plant materials by means of the converter Lumel PP83 connected to   the computer stand which recorded power taken by the pelleting device engine.

The obtained results of energy consumption measurements were compared to the power taken by an engine at idle run (2.6 kW) and energy consumption per mass unit (1 kg) was calculated. Then the obtained results were statistically analysed in order to determine an influence of the percentage of particular plant materials in the prepared mixes on energy consumption during their pelleting.

Table 1. Contents of the plant mixes prepared for pelleting

No.	Material	Mix I (%)	Mix II (%)	Mix III (%)	Mix IV (%)
1.	Oats grain	-	20	25	25
2.	Wheat grain	40	20	25	25
3.	Maize glumelles	20	15	10	-
4.	Maize cobs and straw	20	15	15	-
5.	Sawdust	15	25	20	45
6.	Oil	5	5	5	5

Research Results

By comparing power consumption values for particular plant mixes it should be pointed out that mix I, which was characterized by the lowest power consumption value, consisted mainly of field crops and contained little sawdust.

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And in case of mixes II and III, in which the proportion of field crops was lowered and more sawdust added, power consumption increased by about 34% compared to power consumption for mix I and about 14% compared to the power consumed for mixes II and III.

A statistical analysis of the obtained research results showed significant differences among the power values consumed by the engine running the pelleting machine's working unit depending on the kind of mix used for pellet production (Tab. 2). On the basis on Tukey's test (at the 95% trust interval) the greatest differences were observed between mixes I and IV (0.074 and 0.189 kW·kg⁻¹), and II and IV (0.132 and 0.189 kW·kg⁻¹). However, no statistically significant differences were found between mixes II and III (0.132 and 0.137 kW·kg⁻¹) (Fig. 1).
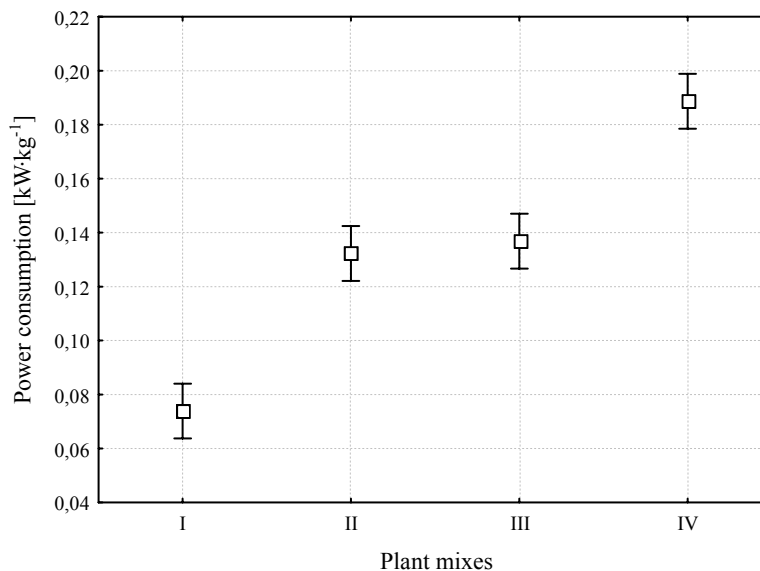
Figure 1. Changes of power consumed by the pelletiung machine's engine depending on type of mix used for pellets production

Table 2. Results of monofactorial variance analysis for energy consumption during pelleting of plant mixes depending on content of particular raw materials

	Sum of squares	Number of freedom degrees	Mean square	Value of F statistics	Significance level α=0.05
Free word	7.07	1	7.07	2642.005	0.00
Mixes	0.66	3	0.22	82.364	0.00
Error	1.06	396	0.003		

Discussion and Conclusions

The lowest power consumed by a pelleting machine's engine (0.074 kW/kg) was observed for mix consisting of ground wheat (40%), post-harvest maize debris (glumes 20%, straw and cobs 20%), sawdust (15%) and plant oil (5%). The highest power consumption (0.189 kW/kg) was observed for mix of ground oats and wheat, 25% each; sawdust 45% and oil 5%. A statistical analysis of the results showed statistically significant differences between power consumption during the pelleting and contents of the applied plant mix. Hence it was proved that an increase of ground wheat and sawdust in plant mixes resulted in an increase of power consumption from 14% to 34% compared to the power consumed for mixes with lower contents of these elements.

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OPPORTUNITIES TO PRODUCE BLACK LOCUST WOOD IN ROWED MIDDLE-FIELD STAND DENSITIES IN AN ASPECT OF APPLICATION FOR ENERGETIC PURPOSES

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Keywords: middle-field stand densities, black locust, energy of biomass

Abstract

The paper evaluates opportunities for producing the black locust wood in rowed middle-field stand densities by means of assessing their productivity and selected physical traits of a wood including division into trunk, branches, and thickness classes in a view of their utilization for a biomass production for energetic purposes.

There is a possibility to produce wood from rowed middle-field black locust stand densities for energetic purposes, and from a point of view of energetic application, the black locust wood has better features than willow wood.

Introduction

The middle-field stand densities play an important role in a balanced agricultural management as a necessary element of rural landscape.
A proper selection of tree and bush species is important at afforestation. Biological features that, due to stand density, make possible to realize not only protective, but also productive functions in a short time, should be also taken into account (Tałałaj and Węgorek, 1996).

Black locust (*Robinia pseudoacacia* L.), the ecological properties of which have attracted some scientists' attention, can be such species (Węgorek, 1994, Pacyniak, 1981).

However, there are no detailed data on the production of black locust wood from middle-field stand densities as well as physical and chemical parameters of that wood that determine its usefulness for energetic purposes.

Undertaken study aimed at evaluating the opportunities for producing the black locust wood in rowed middle-field stand densities by means of assessing their productivity and selected physical traits of a wood including division into trunk, branches, and thickness classes in a view of their utilization for a biomass production for energetic purposes.

Material and Methods

The study was carried out in three 8-year-old rowed middle-field stand densities localized on eroded dust soils (loess) in Snopków near Lublin. Studied stand densities consisted of three-row belts of 5 meters width each, where trees occupied the middle belt with 1.5 m spacing. Rugosa rose bushes grew in edge rows 1.5 m from trees. Stand densities No 1 and 2 were localized on a flat area, while stand density No 3 was situated along the upper line of the valley slope of 15% inclination and southern exposure. No breeding cuts were applied. The nutrient abundance (NPK) of soils under stand density No 1 and No 2 was good, and organic carbon content amounted to 8-10 g·kg^{-1}. Under the stand density No 3, the soil abundance in N_{tot} was insufficient, in P – good, and K – moderate. Organic carbon content was about 5 g·kg^{-1} (Kraszkiewicz, 2007).

In order to evaluate the opportunities for wood achievement from rowed middle-field stand densities No 1-3, the following items were assessed:

a) Tree parameters in stand densities – by means of sample areas of 400 m^2 (stand densities rows of 80 m length and 5 m width):
   – mean height – as arithmetic mean of a tree height measured using height-meter SUUNTO;

- mean breast height diameter – as arithmetic mean of a breast height diameter measured using precision diameter-meter HAGLOF;

b) stand density weight recalculated into 1 ha including division into trunks, branches, and wood thickness classes ($\leq$ 1.0 cm; 1.1-5.0 cm; 5.1-10.0 cm, and more every 5 cm) – by means of sample trees – single tree of medium height and diameter as well as average texture from each sample area (from main and secondary wood) (Bruchwald, 1999); a carrier from the cut site (5-10 cm above ground) to 5-centimeter diameter in bark (upper end) was considered as a trunk, while remaining part (tip) was counted to branches; sample trees were cut at the beginning of January 2005:

- fresh weight of trunks and branches in bark – direct measurement – using scales AXIS B30S;

- dry matter – on a base of samples (representative for particular thickness classes) dried at 105°C – trunks in bark, branches in bark;

- the stand density productivity was calculated as average annual gain of stands expressed in Mg DM·ha^{-1}.

Selected physical determinations of wood included:

- relative moisture content in fresh wood in bark (all stands, trunks, and branches according to thickness classes) – by means of dried-gravimetric method;

- density of dry wood in bark (all stands, trunks, and branches according to thickness classes) – by means of xylometric-gravimetric method;

- calorific value of dry wood in bark (all stands, trunks, and branches according to thickness classes) – using static calorimeter KL-12Mn.

Research Results

Trees occupied ground belts of 5 m width in studies upon rowed middle-field stand densities, hence recalculation of tree number per 1 ha area revealed small density – 1715-1905 trees·ha^{-1}. Mean tree dimensions were uniform and amounted to: 11.5-12.0 cm breast height diameter; 7.5-8.0 m height.

For all 8-year-old stand densities, weight of wood in bark was relatively uniform. Average weight of fresh wood for all three stand densities was 114.52 Mg·ha^{-1}, however, branches made up 35-42% of fresh matter of the whole trees in bark (Table 1).

The amount of average annual wood productivity was from about 10 (stand density No 1 and No 2) to almost 11 Mg·ha^{-1} (stand density No 3).
On average, relative moisture content of trunk and branch wood in stand densities was 34% and 39%, respectively, while for the whole tree − 36%. Moisture content of trunk wood in bark was always lower than that for branch wood in bark. The least difference between moisture content of trunks and branches was recorded in stand density No 1 amounting to 3%, whereas the most in stand density No 2 − 8%. Differences in relative moisture content at fresh wood in particular thickness classes were also found (Table 1).

Mean density of the dry wood of trunks, in bark and the whole trees was 704, 607, and 664 kg·m^{-3}, respectively. Density of the dry trunk wood in bark was higher than that of branches in bark. These differences amounted from 56 (stand density No 2) to 121 kg·m^{-3} (stand density No 1). Densities of the dry wood in bark varied not only depending on the type, but also within the same thickness classes (Table 1). In general, density increased along with the wood thickness, and a slight decrease of the parameter could be observed only in part butt end. Average calorific value of trunk and branch wood was 17.40, 17.47 MJ·kg^{-1} DM, while the whole tree − 17.43 MJ·kg^{-1} DM. As similar as for moisture content and density, differentiation of the calorific value for dry wood in particular thickness classes was recorded (Table 1).

Productivity of 8-year-old black locust middle-field stand densities localized in Snopków near Lublin was satisfactory. The amount of wood mass produced (Table 1) resulted from very good habitat conditions, whereas slight differences in weight could be due to varied tree density.

Table 1. Physical characteristics of researched wood

Stand density No	Thickness classes (cm)	Weight of fresh wood (Mg·ha⁻¹)			Relative moisture content of the fresh wood (%)			Density of the dry wood (kg·m⁻³)			Calorific value of dry wood (MJ·kg⁻¹)		
		trunk	branches	total	trunk	branches	mean	trunk	branches	mean	trunk	branch	mean
1	≤ 1,0	-	12,76	12,76	-	36	36	-	420	420	-	17,76	17,76
	1,1-5,0	-	32,39	32,39	-	42	42	-	690	690	-	17,31	17,31
	5,1-10,0	30,1	-	30,1	39	-	39	770	-	770	17,43	-	17,43
	10,1-15,0	40,96	-	40,96	35	-	35	700	-	700	17,29	-	17,29
	mean or total	**71,06**	**45,15**	**116,21**	**37**	**40**	**38**	**729**	**608**	**683**	**17,35**	**17,45**	**17,39**
2	≤ 1,0	-	8,96	8,96	-	42	42	-	530	530	-	17,78	17,78
	1,1-5,0	-	32,9	32,9	-	39	39	-	550	550	-	17,47	17,47
	5,1-10,0	10,6	4,02	14,62	39	39	39	620	600	615	17,38	17,40	17,40
	10,1-15,0	53,56	-	53,56	31	-	31	600	-	600	17,25	-	17,25
	mean or total	**64,16**	**45,88**	**110,04**	**32**	**40**	**35**	**603**	**547**	**581**	**17,27**	**17,41**	**17,32**
3	≤ 1,0	-	15,78	15,78	-	38	38	-	650	650	-	17,70	17,70
	1,1-5,0	-	18,87	18,87	-	39	39	-	640	640	-	17,51	17,51
	5,1-10,0	33,1	6,86	39,96	33	33	33	780	860	794	17,66	17,53	17,64
	10,1-15,0	42,7	-	42,7	33	-	33	780	-	780	17,54	-	17,54
	mean or total	**75,8**	**41,5**	**117,3**	**33**	**38**	**35**	**780**	**667**	**729**	**17,59**	**17,56**	**17,58**
	Mean in stand densities	**70,34**	**44,18**	**114,52**	**34**	**39**	**36**	**704**	**607**	**664**	**17,40**	**17,47**	**17,43**

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It was observed that relative moisture content of the fresh wood in bark depended on the wood thickness (localization of wood in the tree structure). When comparing the relative moisture content of the fresh wood in bark (about 36%) with literature data for poplar and willow (47-54%) (Szczukowski et al., 2005), black locust wood contained about 1/3 less water than that of willow. It can result in lower energy consumption for water evaporation during combustion as well as lower threat of biological destruction and easier material storage.

Comparison of the density of black locust wood dry matter in bark (664 kg·m^{-3}) with that of poplar and willow that according to Grzybek, *(2004)* and Krzysik, *(1974)* amounted to about 400 kg·m^{-3}, it is apparent that the former was almost by 66% higher.

Mean calorific value of trunk wood in bark was 17.72; branch wood in bark 17.72, and the whole tree wood in bark 17.43 MJ·kg^{-1} DM. In relation to the calorific value of willow wood measured by Grzybek, *(2004)* (18.2 MJ·kg^{-1}),

that of black locust wood in bark was lower, while comparable with oak wood in bark found by Haufa and Wojciechowska, *(1986)* (17.62 – slivers and round timber, and 17.90 MJ·kg^{-1} – branches). Assuming that the calorific value of dry black locust wood is by 4% lower than that of the willow, 1 m^3 of black locust wood can produce almost 60% more energy than from 1 m^3 of willow wood. Therefore, the black locust wood has better properties then the willow or poplar wood in an aspect of its application for energetic purposes.

Conclusions

1. Wood productivity of black locust grown in rowed middle-field stand densities ranges from 10 to 11 Mg·ha^{-1}.
2. Relative moisture content at fresh black locust wood is 36% as compared to that of poplar or willow (about 50%), which is by 1/3 lower.

3. Density of dry black locust wood ranges within 420-794 kg·m⁻³ depending on the type and thickness – 664 kg·m⁻³, on average, which – as compared to poplar or willow wood (400 kg·m⁻³) – which is by 66% higher.

4. The calorific value of 8-year-old black locust wood is lower than that of willow (by 4%) and comparable with that of oak wood.

5. There is a possibility to produce wood from rowed middle-field black locust stand densities for energetic purposes; however, wood achievement should be performed rationally, with no harm for stand density, and in accordance with rules of balanced development.

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SOLID BIOFUELS QUALITY: THE CASE STUDY OF WOOD AND AGRICULTURAL PELLETS

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Keywords: standardisation, wood and straw pellets properties

Abstract

The technical specification CEN/TS 14961 (Fuel specification and classes) plays the central role, among other standards and technical specifications, for Solid Biofuels. On the other hand, both wood and agricultural pellets are biofuels for which the market demand for standard is among the highest. Through the study of wood and agricultural pellets, the quality classes proposed by the CEN/TS 14961 are examined.

First, the influence of the raw material origin (forest, agriculture, agricultural industry, exotic crops etc) is considered. It indeed has a major impact on properties like ash and chemical elements content and consequently on combustion management.

Afterwards, the other properties taken into account by the Technical Specification are presented: dimensions, moisture content, ash content, sulfur content, durability, fines percentage, additives, nitrogen content, calorific value, bulk density, chlorine content, .etc. Overlooked properties as particle density, size distribution of disintegrated pellets, immersion behavior are referred to as well. The properties measurement methods, typical values for commercial fuels and limits regarding the use (domestic, small scale, district heating and electricity producer) are further discussed.

Finally, agricultural and wood pellets are compared and different possible uses are proposed.

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Introduction

In 2000, the European committee for standardisation (CEN) has set up a technical committee (TC 335) to write up standards needed by the solid biofuel sector. Upon its creation, this CEN TC 335 is made up of 5 working groups: WG1 (Terms and definitions), WG2 (Fuel specifications and classes/ Quality assurance), WG3 (Sampling and sample reduction), WG4 (Physical and mechanical properties) and WG5 (Chemical properties) [1].

Today, WG2 has produced a technical specification which uses the technical specifications produced by the other working groups: the CEN/TS 14961 solid biofuels – Fuel specifications and classes [2]. The simple form of this document and the help it gives in the characterisation of solid biofuel quality, make it a major reference on the solid biofuel market. This comprehensive document is made of 3 main parts : first it classify biomass taking into account the origins, second it helps by giving a classification based on physical and chemical properties for different solid biofuels, and third, the last part supply typical values and ranges for a large number of solid biofuels.

Nevertheless, despite all its advantages the document may still be improved. Indeed, no hierarchy between the defined classes is proposed, neither the link between these classes and the possible use of the characterised solid biofuels. Consequently, the document is still difficult to use in practice; especially by the market stakeholders who want to use it as a quality label [3].

A technical specification is a normative document on the way to become a standard, and is allowed to be modified according to public enquiries and market or users possible return [4]. Concerning the CEN/TS 14961, the industry, the consumers and public stakeholders have been questioned to define the improvements needed by the document [3]. In order to take into account the above mentioned aspects, the initial document has been adapted.

Indeed, national contexts are different and given biofuels are more used than other in regional conditions. For instance, in the Walloon region, the demand is

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high (as well from the producers as from the users) for a standard defining a hierarchy for wood pellets qualities. Other standards would be of interest too; briquettes, wood logs, wood chips…   This paper will focus on the pellets properties regarding their use.

Main solid biofuels properties

Pellets share several properties with other solid biofuels: chemical composition, moisture content, ash content or calorific value.   Pellets have also specific physical and mechanical properties, which are less influenced by the raw material origin than by the production process. Several measurement methods of these properties have been standardised and are now on technical specification stage.   Most of these properties are described here after: durability, fines fraction, particle density, internal particle size distribution, bulk density, length and diameter.

Moisture content

Moisture content expresses the water amount that may be delivered by a fuel [5]. It is measured by placing a sample fuel in a drying cabinet in specific conditions [6-8].
This parameter has obviously a main influence on the energy amount that a fuel may deliver. Due to the hygroscopic characteristic of pellets and to the moisture constraints imposed by production process, pellets have a narrow range of moisture. In practice, pellets moisture content rarely excess 15%.

The calorific value

The calorific value is the energy amount per mass unit released on complete combustion of a fuel. It is expressed in MJ/kg [5].
Both net calorific value (q_{net}) and gross calorific values (q_{gr}) may be used to characterise a fuel.   The q_{gr} is a measured value (using a calorimetric bomb) which includes the heat released by the water vapour condensation. The q_{net} is a calculated value based on the q_{gr} from which the heat amount corresponding to the vapour condensation is taken off [9, 10].

In case of domestic or medium scale use, the Austrian standard recommends a q_{net} minimum value of 18 MJ/kg [11]. Using pellets as fuel for electricity production at the "Awhirs" power plant, Electrabel requires of minimum of 17 MJ/kg [12].

Pellets calorific value is influenced by its moisture and the raw material ash content [9, 13].

Ash content

Ash content is defined as the mass of inorganic residues after fuel combustion, in specific conditions. It is calculated as a percentage of the anhydrous mass of the fuel. From the physical properties point of view, ash content mainly acts on the calorific value, due to weight effect, by decreasing the energetic content of the fuel sample [9].

Bulk density

The bulk density of a solid biofuel is the "*mass of a portion of a solid fuel divided by the volume of the container which is filled by that portion under* specific *conditions*" [5]. Typical bulk density values for wood pellets ranges from 500 to 750 kg/m³, for pure wood.

Particle density

The particle density of a solid biofuel is the ratio between the mass and the volume of a single particle of this material [5]. Typical values for pellets particle density range from 0,620 to 1,350 kg/dm³ in case of wood. For straw pellets values from 0.95 to 1.3.23 kg/dm³ have been recorded. The Austrian standards [11] recommends for domestic use, pellets having a particle density over 1,0 kg/m³.

Particle size distribution

The particle size distribution of a solid biofuel is the proportion of various size of the fuel particles, as determined [5]. This property is generally measured by an appropriate set of sieve. In case of pellets, it is the length and the diameter of the pellets which are of interest. Due to the breakability of pellets, these values

are hand measured with callipers. Length and diameter are important to control because a single long pellet (over 45 mm) may disturb the supply of domestic boilers (air flow or screw) [14]. Moreover the length and diameter are directly linked to combustion properties [13].

Pellets internal particle size

The pellets internal particle size is a typical specification from users who mill the pellets before using it as wood particles (power plants, co-firing) [12]. The method developed to measure that property is based on pellets disintegration in water, in specific conditions. After treatment, the mixture is dried (in a drying cabinet) and placed in the laboratory upon having reached the moisture equilibrium with the atmosphere. The material is then sieved using the same set of sieve as described for particle size distribution [15]. Electrabel for its Awhirs power plant has set up the median value of this distribution at 1,0 mm.

Durability

Durability expresses the pellets resistance towards shocks and abrasion due to transport and handling [16]. The measuring method selected by CEN to measure durability requires the sample to be subjected to controlled chocks [17]. Chocks are due to the pellets collision against each other and against the walls of the test chamber. Durability is expressed as the percentage of material which doesn't pass through a 3,15 mm round holes sieve after the treatment Generally, pellets durability ranges from 92,0 up to 99,7%. To be used in domestic or medium scale applications, the advisable limit is 97,5% [2].

Fine fraction

Prior to durability measurement, the fines content is determined by sieving 500 g pellets (as received). The amount of fines is calculated as a percentage of the initial sample mass. Due to transport conditions influence on this property, it is important to specify where the sample is originating. Fines have been recorded as having a negative influence on human health [13, 14], it is as well one major disadvantage listed by the small scale pellets user [18]

Influence of solid biofuel origin on the fuel quality

Influence of raw material components on combustion

Whatever the final form of the solid biofuel : chipped, dried, densified material... the origin, the raw material determines several fuel properties. Indeed, the content in ash, nitrogen, sulphur, potassium, chlorine, for instance, is quite different for the different biomass origins (forest, agriculture, industry...). And these elements are known to have a significant influence on the combustion and associated emissions [5]. Before describing the fuel influence on that matter, it has to be reminded that the main influencing factor on emission from combustion is the yield and the quality of the combustion system itself, especially for small scale units [19-21].

High ash content may lead to slag formation and fouling. In consequence, this property determines the combustion technology and the cost of the ash cleaning equipment. Moreover high ash content may cause emissions of dust, fine particles, flying ashes, it also has an influence on gas corrosion, ash melting, NO_x, aerosol [22-24]...

The Nitrogen content is directly linked to NO_x (NO & NO_2), which have a negative impact on human health, especially on the respiratory tract, NO_2 is moreover toxic. In addition, these elements further the greenhouse effect, acid precipitations, smog and aerosols formation. Finally, these compounds are corrosive and their presence is responsible of material damage [25].
The sulphur presence in a fuel make the production of SO_x (SO_2 & SO_3) possible, these compounds have a negative impact on human health, especially on the respiratory tract (asthma). On the climatic and environmental point of view these elements take part in aerosol formation, acid precipitations and smog. Gases containing SO_x are corrosive and cause damage to combustion and gas evacuation systems [25].

Potassium decreases the ash melting temperature and lead to corrosive gas production, aerosols and fine particles emissions [25].

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Chlorine leads to HCl production, which has a negative impact on human health and is responsible for corrosion. Further it has a role in dioxins and furans formation, which are highly toxic. On the environmental point of view this element is responsible for acid precipitations [25].

Corrosion due to smokes requires to adapt the conversion system and to clean combustion gas. In consequence, appropriate materials are selected for the combustion units and adapted coatings of the boiler tubes are used. The presence of dioxins or furans imposes the use of catalytic converters or sorption with activated carbon [25].

Influence of biomass origin on compound content

In order to illustrate typical contents for different compounds, values listed in annex A of technical specification CEN TS 14961 [2] have been gathered in four main origins or groups. Group 1 involves solid biofuels made of wood, Group 2 involves agricultural productions, Group 3 involves fruit industry residues and Group 4 presents non European biomasses. These groups and fuels they contain are listed in table 1. Following figures present typical values of these solid biofuels, associated, when available, to maximum and minimum admissible values.

Table 1: Fuel groups (Group I: Forest fuels, Group II: Agricultural fuels, Group III: Fruits industry fuels & Group IV: examples of tropical fuels) & abbreviations used for the figures

Group	Fuel	Abbreviation
Group I	Coniferous wood	WC
	Deciduous wood	WD
	Logging residues Coniferous	LRC
	Logging residues Deciduous	LRD
	Salix Short rotation Coppice	SRCS
	Polar Short rotation Coppice	SRCP
	Bark from coniferous	BC
	Bark from deciduous	BD
Group II	Grain (wheat, barley, rye...)	Gr
	Miscanthus	M
	Cereal Straw	SC
	Rape Straw	SR
	Rape grain	GrR
	Reed Canary Grass Spring Harvest	RCGS
	Reed Canary Grass Summer Harvest	RCGSm
	Grass in general	G
Group III	Fruit stones (Apricot, Cherry, ...)	FSt
	Crude Grape cake	GCC
	Fruits shells (almond, hazelnut,	FSh
	Exhausted olive cake	Ol Ex
	Exhausted grape cake	GC Ex
	Crude olive cake	Ol CC
Group IV	Coton gin trash	Ct
	Sun flower husk	SFl
	Cotton stalks	CS

Calorific value

It is well known that the origin has minor influence on the calorific value of a solid biofuel [9]. This is confirmed by figure 1 , which shows it is generally less than 20 MJ/kg for lignocellulosic materials. But vegetal oil content of the raw material may be responsible of an increase of this value, which is illustrated by

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the higher value for grape seeds and to a lower extend by fruit stones calorific values, in the figure.
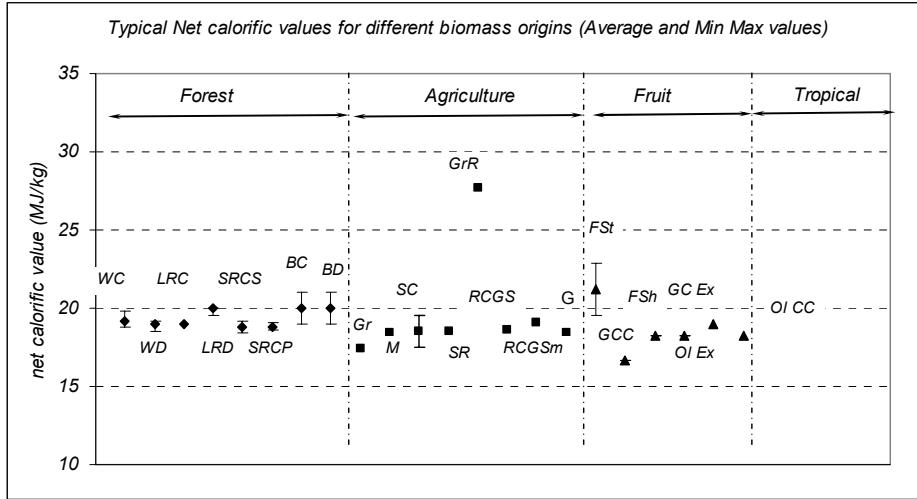

Figure 1: Net calorific value for four groups of biofuels origins (see table 1 for abbreviations)

Ash content
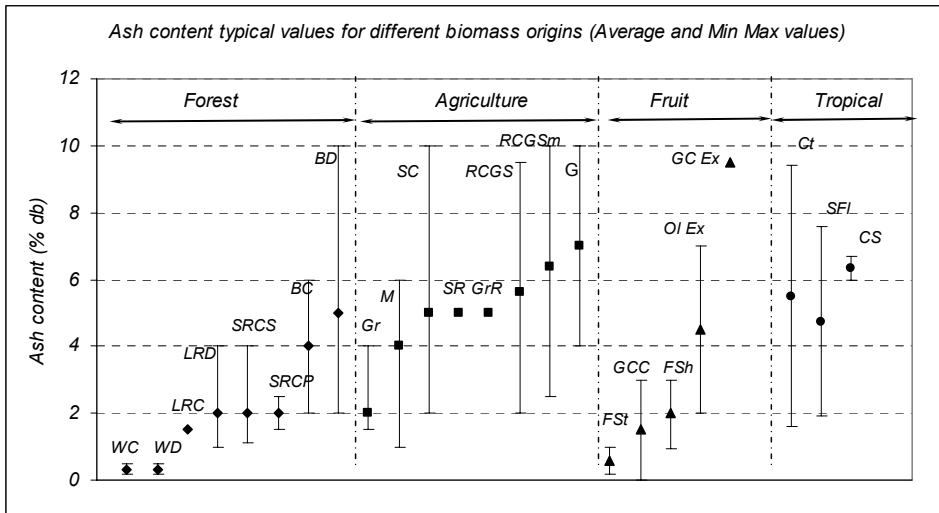
Figure 2: Ash content value for four groups of biofuels origins (see table 1 for abbreviations)

Contrary to calorific value, clear differences appear for ash content arising from different origins. Agricultural material ash content is generally higher compared to other origins (forest & fruits). As illustrated by figure 2 wood has low ash content. The ash content increases with thepossibility, for the material, to have been in direct contact with the ground. It also increases with bark rate. But in both cases ash content is lower for wood compared to agricultural productions.

Nitrogen content
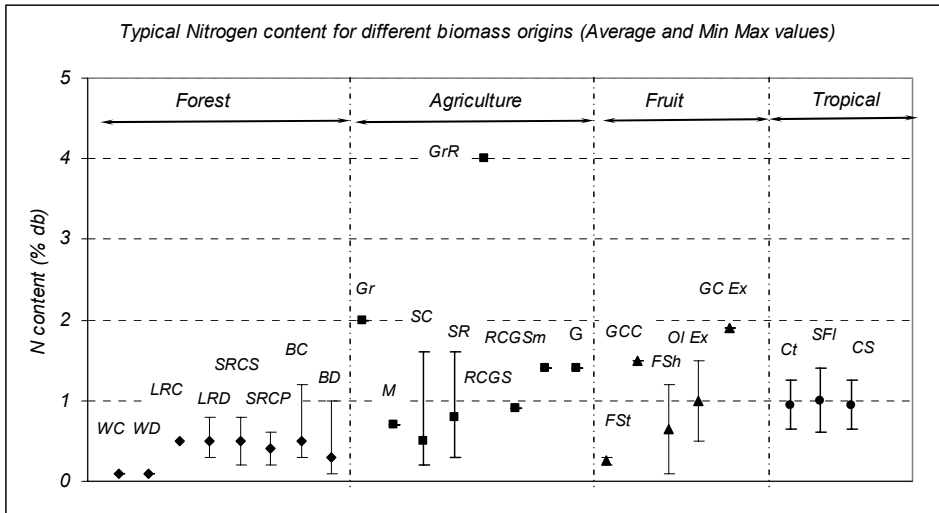
Figure 3: Nitrogen content value for four groups of biofuels origins (see table 1 for abbreviations)

As illustrated by figure 3, Nitrogen content for forest products are lower compared to agricultural products. Especially, rape seeds contain high nitrogen concentrations.

Sulfur content

Figure 4: Sulfur content value for four groups of biofuels origins (see table 1 for abbreviations)

Compared to agricultural production, Sulphur content is lower for forest products as well, see figure 4. It is to be noted that fruits stones may contain high sulphur concentrations.
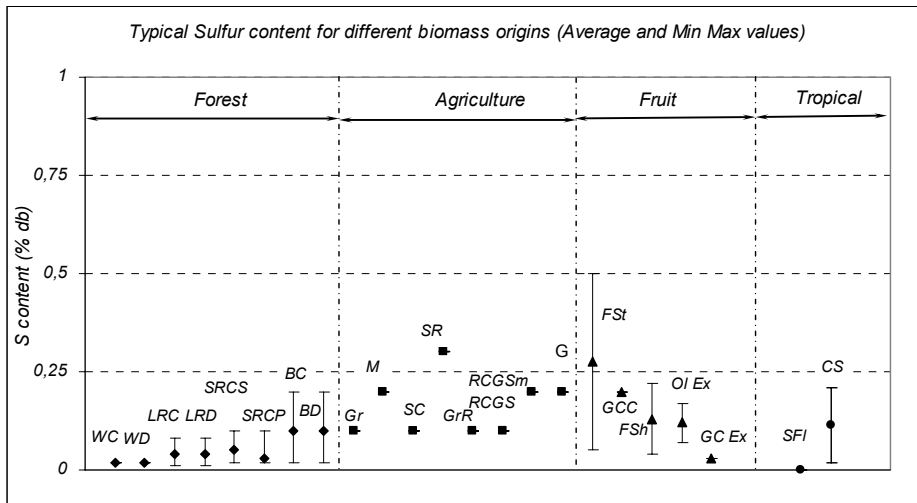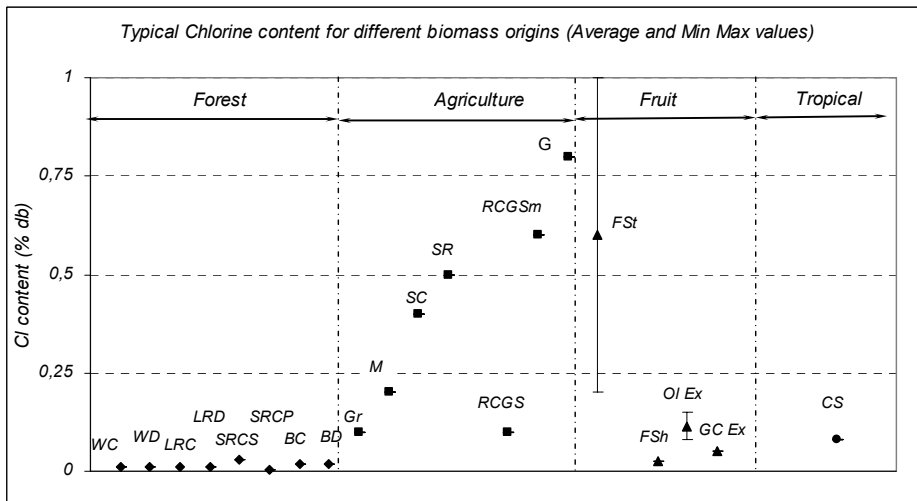
Chlorine content

Figure 5: Chlorine content value for four groups of biofuels origins (see table 1 for abbreviations)

As for the other considered elements, forest products have lower chlorine content compared to agricultural products, see figure 5.

Consequences regarding pellets quality

The here above described properties and origins are useful to characterise pellets. However, pellets quality has to be linked to the actual use of the fuel. In this respect, three scales of uses may be considered. At one side, the domestic use, stoves and small scales boilers, are mostly lacking in smoke treatment and don't provide reasoned ash cleaning systems. On the other side, electrical power plants using pellets either as single fuel or as biomass source for co-combustion with coal or gas. In this late case, smoke and ash cleaning systems are set up and combustion downstream is controlled. Between these two cases, medium power producers, as district heating boilers, have to be considered. Obviously, the needs and requirements in pellet quality for these users are different.

Due to the scale of use, an electricity producer is able to obtain a faster return on the investments made to clean combustion gases and to eliminate ashes. In consequence, these consumers are able to use a wider range of pellets qualities.

The quality specifications are generally defined between the pellets consumer and a specialised trader. On the other hand, emissions risk due to the raw material origin for medium and small scale users are higher, due to difficulties the clean gas in a cost-effective way. Moreover, trials have been performed on agricultural pellets [26-27], it shows, for small scale devices, problematic combustion with slag formation and high fouling. These problems seem to be possible to overcome by adding additives or by mixing agricultural products with a high wood proportion. But, at this stage, no rules have been set up. More practice and trials are needed before the small and medium scale combustion of agricultural pellets becomes safe and under control.

In consequence, the raw material for pellets used in small and medium scales should be limited to wood. Suggested threshold values regarding the pellets scale of use are defined in table 2.

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Table 2: Pellets suggest threshold values for small and medium scale uses

Properties	Small scale	Medium scale
Origin according to [2]	Forest, plantations and other virgin woods (Class 1.1) By-products and residues from wood processing industry (Class 1.2.)	
Diameter (D), length (L) (mm)	D: 6 or 8 mm, L max 40 mm	D: 6 or 8 mm, L max 45 mm
Moisture content (w-%) (M)	M $\leq$ 10%	M $\leq$ 10%
Ash (w-% dry basis (A)	A $\leq$ 0,5%	A $\leq$ 1,5%
Mechanical durability (w-% after testing) (DU)	DU $\geq$ 97,5%	DU $\geq$ 96,5%
Amount of fines (w-%) at consumer delivery (F)	F $\leq$ 1,0%	M $\leq$ 2,0%
Additives (w-%) (Ad) – type and amount to be stated	Ad $\leq$ 2%	Ad $\leq$ 2%
Bulk density (kg/m³) (BD)	BD $\geq$ 625	BD $\geq$ 625
Nitrogen (w-% dry basis) (N)	N $\leq$ 0,03%	N $\leq$ 0,05%
Sulphur (w-% dry basis) (S)	S $\leq$ 0,02%	S $\leq$ 0,05%
Chlorine (w-% dry basis) (Cl)	Cl $\leq$ 0,02%	Cl $\leq$ 0,05%

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ECONOMICAL ALTERNATIVE TO THE SUBSOIL HEAT EXCHANGER FOR FARROWING HOUSES

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Keywords: geothermal heat, heat exchanger, climatization, pig house

Abstract

Subsoil heat exchangers with corrugated pipes have proved to be very efficient for air conditioning in farrowing houses. However, they require high investments. Therefore a less expensive alternative has been tested. The outside air, instead of flowing through pipes, crosses a cavity under the floor plate before entering the house. Measurements carried out over a whole year prove that due to the heat exchange between air, soil, side walls and the underside of the floor plate the temperature of the incoming air increases up to 12°C during winter and reduces up to 6 °C during summer. The fluctuations of the outside temperature are reduced by 60 to 75% in the annual average. Due to the cooling of the incoming air the inside temperature can be limited to 28 °C during the summer. In comparison to the subsoil heat exchanger the cavity under the floor plate causes only small extra costs. A three-dimensional non-steady-state heat flow model has been developed in order to simulate heat transfer in the soil and the temperature of the incoming air.

Introduction

In the 1980s the first subsoil heat exchangers for the air conditioning of pig houses have been built in Switzerland. In 1995-2001 research has been carried out on an experimental subsoil heat exchanger at the research station ART in Tänikon resulting in a three-dimensional non-steady-state heat flow model that

can simulate the heat transfer between the air circulating in the tubes and the surrounding ground (Deglin et al., 1999). Temperature measurements over a whole year prove that the air temperature at the end of the pipes varies only little between day and night, when the heat exchanger is correctly designed. However, subsoil heat exchangers are very expensive. Therefore the ART has started researching an economical alternative of geothermal heat use.

Materials and Methods

The investigated alternative consists of a cavity under the floor plate through which the fresh air is flowing before entering the animal house. To this end a farrowing house (8.32 x 35.32 m, 20 farrowing pens) has been built with a prefabricated floor plate put on two lateral slurry channels and a middle wall (fig. 1). The cavity is divided by the central wall in two parts of about 3.5 m in width and 0.6 m in height. The central wall is perforated so the air can pass from one side to the other. The fresh air is taken from the cavity by a fan and distributed in the pig house through shafts. Besides an electrical heating plate (200 W) in each farrowing pen there is no room heater in the pig house. The air temperature has been continuously measured (every 0.5 h) from July 2005 until June 2006 at the outside, the inside and in the farrowing pens 4 and 17 (incoming air, fig. 2). The measurement results have been compared to the data obtained with a subsoil heat exchanger with corrugated pipes in 1999 and 2000.

Figure 1: Prefabricated floor plate forming together with the lateral slurry channels, the central wall and the soil a cavity

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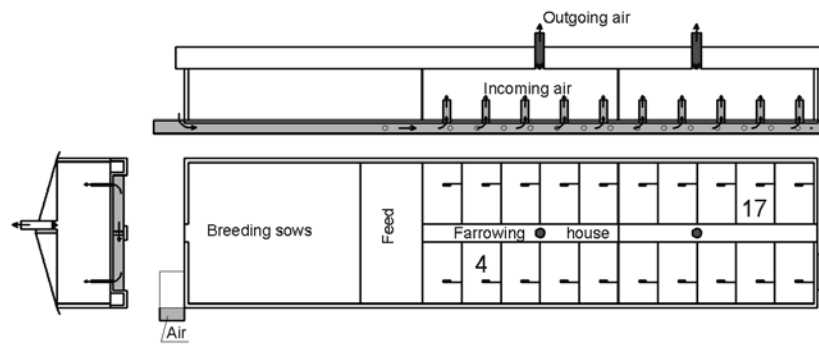
Figure 2: Pig house with 20 farrowing pens. The air is passing through a cavity under the floor plate before entering the pig house

The travel distance of the air in the cavity is 18 m until it reaches pen 4 and 35 m until it reaches pen 17. The measurement results are compared to previous data obtained with a subsoil heat exchanger consisting of three 39 m long corrugated pipes with a diameter of 402 mm, 2 m deep under the ground level.

Results

Heat exchange in the cavity under the floor plate

The temperature of the air after passing the cavity depends, as expected, on the travel distance. In pen 4 the minimum temperature is −3.2 °C; in pen 17 it's 0.1 °C (fig. 3) at an outside temperature of −12.3 °C. During December 2005, the average temperature of the incoming air in pen 17 is about 2.4 °C higher than in pen 4. The maximum amplitude of the incoming air in pen 4 is about 8.5 °C during 24 hours; in pen 17 it's only 5.1 °C. On this day, the fluctuation of the outside temperature amounts to 18.4 °C.
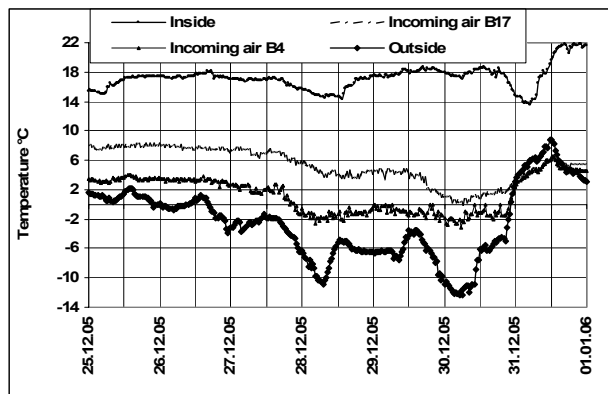
Figure 3: Evolution of the outside and inside temperature as well as of the temperature of the air after travelling 18 m (B4) and 35 m (B17) in the cavity under the floor plate (see fig. 2)

During the summer the maximum temperature of the incoming air is 26 °C in pen 4 and 23.2 °C in pen 17 (fig. 4). The outside temperature is 33.7 °C at this moment. The average day-night temperature fluctuations of the incoming air amounts to about 7 °C in pen 4 and 4 °C in pen 17 during the hottest period.
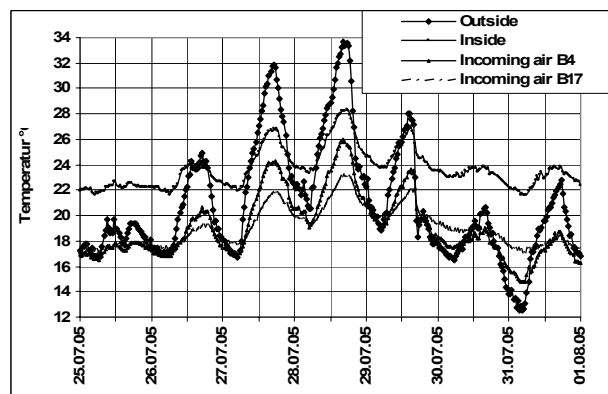
Figure 4: Because of the longer distance the temperature of the incoming air is lower in pen 17 (B17) than in pen 4 (B4)

Over the whole year they are on average 3.2°C in pen 4, 2.0°C in pen 17 and 7.9°C at the outside.

The ventilation rate being between 1600 m³/h and 6000 m³/h the calculated heat exchange in the cavity under the pig house amounts to about 8300 kWh (fig. 5) for the winter 05–06 (November until March). During July–September 2005 und May–June 2006 the cavity cools the air by about 7300 kWh. The cooling rate is lower than the heating rate in spite of the higher ventilation rate during summer. This is on the one hand due to the cold winter of 2005–2006 and rather cool summer (2005) and on the other hand due to the heat transfer through the floor plate. This heat transfer increases the temperature of the incoming air, which is advantageous during winter but unfavourable during summer.
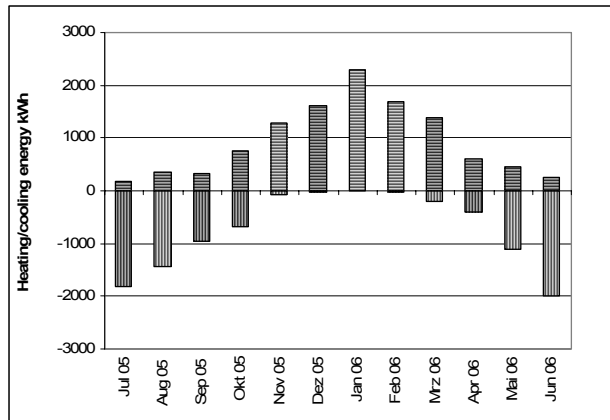
Figure 5: Heat exchange in the cavity under the floor plate. Positive values mean heating, negative values mean cooling

Heat exchange in the subsoil heat exchanger with corrugated pipes
During the winter of 1999-2000 the temperature at the end of three 39 m long corrugated pipes does not drop under −2 °C even at outside conditions of −18 °C (fig 6). This is due to the release of latent heat by the phase change of the water in the soil. The temperature variation of the air at the end of the pipes is less than 3 °C within 24 hours during winter.
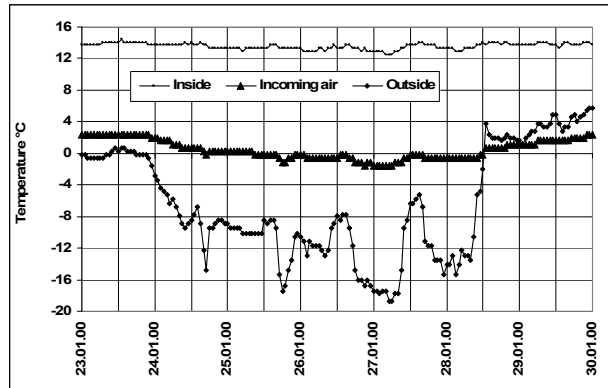
Figure 6: Evolution of the outside and indoor temperature as well as at the end of the subsoil heat exchanger

During the summer of 2000 the maximum air temperature at the end of the pipes is 22.3 °C (outside temperature 30.6 °C) (fig. 7). The day-night temperature amplitude is maximal 6.5 °C. The fluctuation of the outside temperature is 21 °C on the same day. For the whole year the average day-night temperature variation is 9.5 °C for the outside air and 2.3 °C for the air leaving the subsoil heat exchanger.
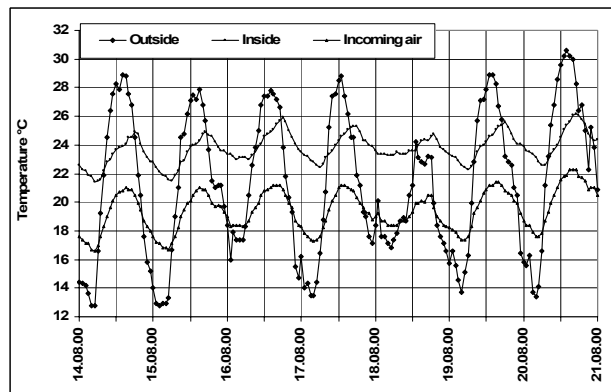
Figure 7: The average day-night air temperature amplitude during the period 14.08.00 – 21.08.00 is 16 °C at the outside, 4 °C at the end of the pipes and 3.5 °C inside

The subsoil heat exchanger is continuously fluctuating between the heating and cooling modus depending on the variations of the outside temperature. The total

heat release during January-March and November-December 2000 is 5300 KWh (fig. 8). The heat absorption (cooling) during May-September 2000 amounts to 6700 kWh. The calculated maximum cooling power exceeds 15 kW for a ventilation rate of 4800 m³/h.
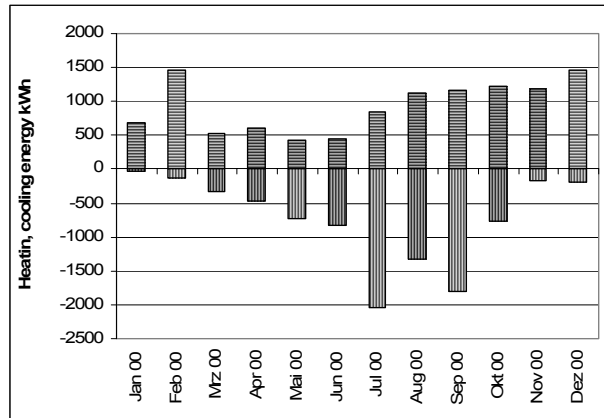
Figure 8: Heating and cooling of a subsoil heat exchanger with corrugated pipes (3 ⌀402 mm, L=39 m) in 2000. Minimum ventilation rate: 1600 m³/h; maximum rate: 4800 m³/h

Discussions

The bigger the available surface of the cavity and the smaller the air speed, the bigger the heat exchange per m³ ventilation rate. Thanks to the recuperation of the heat losses through the floor plate the heating power of the cavity is comparable to the one of a subsoil heat exchanger. According to the measurement results a heat exchanging surface with the soil of about 0.025 m² per m³/h ventilation rate is required for cooling down the air by 6°C. This is less than realised by a subsoil heat exchanger next to the building (up to 10 °C). If the surface of the cavity is smaller than 0.025 m² per m³/h ventilation rate, its cooling or heating performance will be less important. Unlike the subsoil heat exchanger, the size of the cavity under the animal house cannot be freely chosen, but is defined by the dimensions of the building itself.

Depending on the diameter of the corrugated pipes, subsoil heat exchangers in Switzerland require investments between 1,000 and 1,500 CHF per farrowing pen. Building a cavity under the floor plate is less expensive. By using prefabricated concrete slabs, costs can be limited to about 300 CHF per

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farrowing pen. Ventilating through a cavity reduces the energy to heat the farrowing house by about 300 kWh per year and farrowing pen. Assuming a price of 0.16 CHF per kWh and a depreciation period of 25 years the annual return on investments amounts to 12%. Consequently building a cavity is already profitable only by reducing the heating. Contrary to the cavity a subsoil heat exchanger with corrugated pipes also needs a better animal performance to be economical.

Summary

With regard to using geothermal heat, a cavity under the floor plate can be an economical alternative to the subsoil heat exchanger with corrugated pipes next to the building. Temperature measurements carried out over a whole year in an experimental farrowing house with a cavity prove that on cold days the air temperature can be raised up to 12 °C, comparable to previous results obtained with a subsoil heat exchanger with corrugated pipes. During hot periods the cavity is not so powerful in regard to cooling than the subsoil heat exchanger. However, it can be expected that the temperature of the incoming air does not exceed 26°C at an outside temperature of 32°C, provided that the cavity surface is not less than 0.025 m^2 pro m^3/h ventilation rate. Thanks to its relative small investment costs ventilation through a cavity is already profitable alone by reducing the heating costs. This is not the case for subsoil heat exchangers.

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EVALUATION

DESIGN AND APPLICATION OF MOTIFS: AN INTEGRATED MONITORING TOOL FOR SUSTAINABLE FARMING

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Abstract

In order to make the 'sustainability concept' tangible on farm level, MOTIFS - an indicator-based Monitoring Tool for Integrated Farm Sustainability- was designed in Flanders. MOTIFS is a graphical tool which integrates indicators for economic, ecological and social sustainability. This paper describes two types of applications of MOTIFS on Flemish dairy farms, which are used to introduce the tool into practice and to optimise the tool and its application. Potential end-users found MOTIFS useful to get an overview of a farm's sustainability and perceived it as a valuable communication tool. However, assistance in the use of MOTIFS, computerisation and additional farm information are necessary to ensure the application of MOTIFS and to facilitate decision processes.

Introduction

The importance of sustainable farming is currently no longer contested. A typical example are the latest reforms of the European Common Agricultural Policy (CAP). While the early CAP focussed on encouraging better agricultural productivity, recently an emphasis was placed on sustainable farming. Farmers still receive direct income payments, but the link to production has been reduced. In addition, farmers have to respect environmental, food safety, phyt osanitary

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and animal welfare standards. Farmers who fail to do this will face reductions in their direct payments. Thus while European farmers are more and more subjected to economic pressure and competition, they are also expected to undertake considerable efforts to meet society's ecological and social wishes. Farm management with attention for integrated sustainability is therefore crucial, but in practice still difficult to apply. An explicit need exists to make sustainability understandable and applicable in practice.

In order to convert the theoretical concept of sustainability into a tangible concept at farm level, an indicator-based Monitoring Tool for Integrated Farm Sustainability (MOTIFS) was designed in Flanders (Figure1) *(Meul et al., 2008a)*.
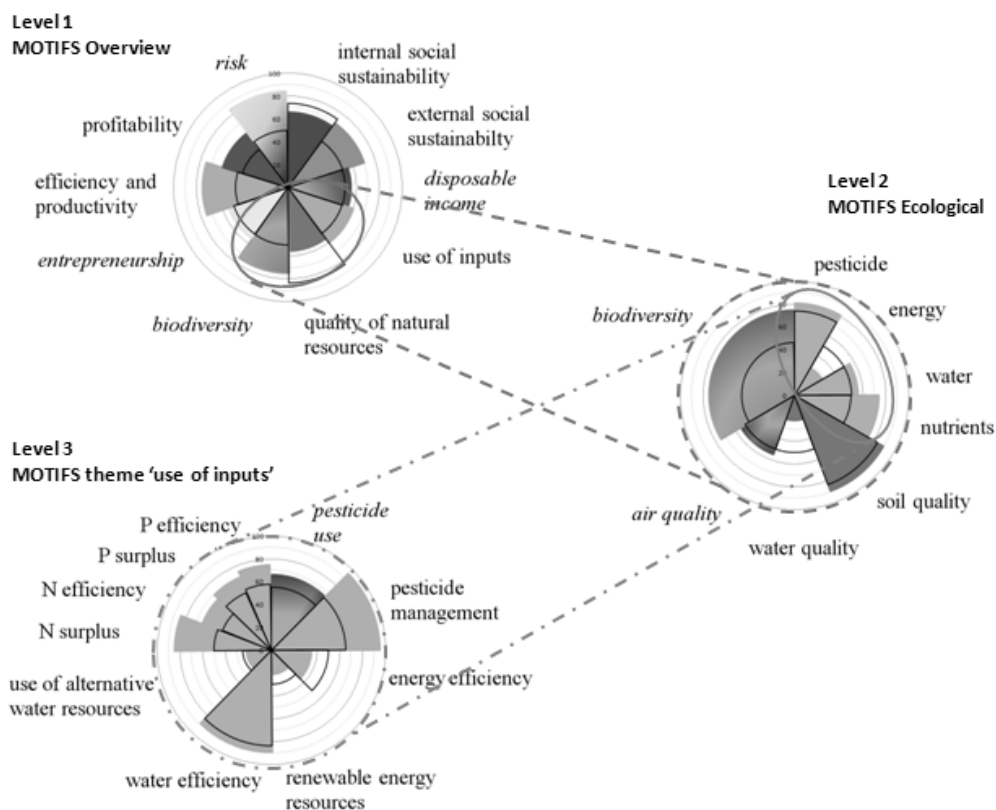

Figure 1. The 1st level of MOTIFS gives an overview of the integrated farm sustainability. Level 2 zooms in on the 3 sustainability dimensions. The indicator scores of level 3 make the sustainability themes concrete.

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MOTIFS is a graphical tool which integrates indicators for economic, ecological and social sustainability themes and sustainable entrepreneurship. The principle of equality of the economic, ecological and social dimension is reflected in an equal width of each dimension. Entrepreneurship is added as a separate theme because of its importance for all three dimensions. The first level of MOTIFS allows for an immediate and holistic interpretation of the farm's overall sustainability and gives an overview of the farm's strengths and weaknesses. In level 2 we can zoom in on the three sustainability dimensions of MOTIFS (Figure 1). Further zooming in, results in the visualisation of the indicator scores for a specific theme (level 3, Figure 1). The indicators make the themes tangible and allow to measure, monitor and steer the sustainability on farm level. Each indicator value is set on a scale between 0 (not sustainable) and 100 (sustainable), through which the different components of a farm can be evaluated individually as well as be interpreted as a whole.

As many other theoretical tools that are designed for practical use, it is necessary to test MOTIFS in actual practice. This paper describes two applications of MOTIFS on dairy farms. Both are used to introduce the tool into practice and to validate its end-use value, which allows optimising and continuously improving the tool and its application.

Materials and Methods

Two types of application of MOTIFS on Flemish specialised dairy farmswere investigated (1) in an European Leader+ project, and (2) in two existing farmer groups from farm consultancy agencies. These applications allowed us to obtain an overview of the opportunities and bottlenecks for future applications of MOTIFS.

First, MOTIFS was applied on 20 Flemish dairy farms participating in the Leader+ project 'Strong with Milk, 2006-2008' with the aim to monitor sustainability and stimulate communication and exchange of knowledge between dairy farmers. At the start of the project, a number of sustainability themes (economic, ecological and social), extracted from MOTIFS, were selected. The

project leader regularly collected on-farm data through farm accountings and direct farmer inquiries, calculated the indicators and discussed the results with each farmer individually. Additionally, discussion sessions were organised for all participating farmers in which their results for a certain sustainability theme were discussed, together with an invited expert. In a second, on-going application, MOTIFS is being used by two groups of dairy farmers that are member of two different farm consultancy agencies. The farmer groups consisted of about 10 farmers who meet on a regular basis to discuss their farm economic accounting under guidance of a farm consultant. In contrast with the first type of MOTIFS application, the data already available in the farm accountings (economic and environmental) were linked to a basic system for automatic calculation of MOTIFS. This was done in close cooperation with the farm consultants and programmers of the agencies. As none of the necessary data for calculating social indicators were registered, social themes are not yet dealt with in this on-going application. The discussion of the sustainability results was integrated in the regular farmer meetings that are directed by the farm consultant. The first meeting elaborated the entire tool and its principles, while following meetings dealt with a specific theme. In both applications, feedback on the end-use value of MOTIFS was gathered through semi-structured interviews and questionnaires with the potential end-users (farmers and farm consultants) and direct observations in farmer meetings.

Research Results and Discussion

The two applications of MOTIFS learned that both farmers and farm consultants find the tool useful to give an objective overview of all important sustainability aspects of a farm and its management. It is a good starting point to touch upon other than only economic and technical issues, as is usually done in the regular farmer meetings. Particularly the farm consultants indicate it as a practical tool to base their advice on and to steer farmers towards a larger awareness of an integrated sustainable farm management. However, it becomes clear from the use of MOTIFS that it takes time to get familiar with the type of presentation. Moreover, it is not easy to understand and interpret the results of some indicators that are new to farmers and consultants. In line with the innovation

theory of *Rogers (1995)*, this degree of complexity can slow down the rate of adoption of MOTIFS by potential end-users. Therefore it is important to provide assistance in the use of MOTIFS and the interpretation of the results at the initial stage *(Halberg, 1999)*. Through this, the complexity of the tool can be counteracted.

From the 'Strong with Milk' project, it already became clear that farmers are not interested to use MOTIFS if they would have to invest a lot of time. In order to allow an effective and efficient use of MOTIFS, the data collection and indicator calculation need to be computerised as much as possible. The cooperation with the farm consultancy agencies permits the development of a user-friendly computer-based system that is integrated in their existing accounting programs in order to easily calculate MOTIFS. In this way, a maximum use of available farm accountancy data is made. Moreover, a minimum of extra time should be invested by farmers or farm consultants to collect other types of data that currently are not systematically registered (mostly social data).

The 'Strong with Milk' project demonstrated that MOTIFS can be a valuable communication tool since it allows to compare individual farm results and to discuss about tangible aspects of farm management in farmer meetings.
However, it became clear that additional information and hard figures are necessary to take real management decisions or to formulate specific advice *(Meul et al., 2008b)*. Also *Schröder et al. (2003)* stated that one needs to be careful in drawing conclusions from indicator results without looking at farm-specific data. Such as many other indicator-based systems, MOTIFS does not propose directly which measures a farmer need to take in order to improve the sustainability of a farm component. To be successful, the use of indicators to improve the sustainability performance of farms must be linked to advisory activities *(Öbron et al., 2003; Halberg et al., 2005)*. The use of MOTIFS together with consultancy agencies and in farmer meetings should therefore be stimulated. This allows farmers to communicate in a concrete way about sustainability, to exchange knowledge and find solutions for specific problems.

The application of MOTIFS by the farm consultancy agencies has until now shown some different findings than the project 'Strong with Milk'. An important difference is that MOTIFS needs to be integrated in the existing advisory system of the agencies, which brings about some restrictions. Farm consultants are still mostly economic-technically oriented with a strong focus on current farm income. By using MOTIFS, farm consultancies are challenged to incorporate other sustainability aspects in their advisory activities. Even though they want to broaden their view, it seems difficult to change their usual practices. Accordingly, they try to deal only with the economic-technical aspects of MOTIFS and tend to leave the overall idea of MOTIFS aside. Moreover, they like to develop extra MOTIFS graphs that integrate more technical indicators because their results lead to more detailed technical advice. According to *Goodlass et al. (2003)*, the willingness of farmers to use indicator-based tools is higher if they are linked to technical advice. Possibilities need to be examined for adapting MOTIFS so to keep the overall sustainability idea, but also include a more technical level that makes it easier for consultants to give concrete advice.

Conclusions

The progress towards a sustainable agricultural production can only be made when farmers are offered concrete tools that lead to sustainable practical measures. MOTIFS is an indicator-based tool that systematises integrated sustainability and allows to measure, monitor and steer the level of sustainability on a farm. However, a tool like MOTIFS is only useful if it is understood and accepted by the potential end-users. Current applications of MOTIFS show a positive attitude towards the tool as positioning tool - giving insight in the farm's sustainability, its strengths and weaknesses - and as communication tool in farmer meetings, allowing to compare results, to exchange knowledge and to increase awareness of the importance of sustainable farming. A way to ensure the application of MOTIFS is to increase the user-friendliness of the tool by developing a computer-based system and to provide assistance in the interpretation of results. Additionally, to ensure that the use of MOTIFS in farmer meetings is followed by actions, it is crucial to create a balance between the MOTIFS results and other farm information. MOTIFS does not give an answer by

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itself of the 'best measure' to improve the farm sustainability; it provides a basis for decisions by giving indications of possible intervention points. Combined with discussions among farmers and advisors, detailed farm data and other types of information, MOTIFS can potentially facilitate actions and be a surplus value to existing advisory systems.

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COMBINING FEED, FOOD AND NON-FOOD USES OF LUPIN FOR SUSTAINABILITY

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Abstract

Lupin is a grain legume cultivated mainly for its grains which are used in animal feed. This crop has some advantages in terms of sustainability, but its cost-efficiency depends largely on the weather and the soya market. To investigate improving its profitability, we fractionated lupin seed to isolate the protein for animal feed and to characterize the lipid and fibre parts in order to find new uses for them in high value-added sectors.

The results showed that the oil extraction technique, whether the Soxhlet method or supercritical CO_2 is used, had little effect on the oil composition. *Lupinus albus* contained more lipids than *Lupinus angustifolius* (7.8 *vs.* 4.8%) and had a better

fatty acid pattern with regard to human health (lower $\omega6/\omega3$ ratio [2.1 *vs.* 6.3] and fewer saturated fatty acids [12.9 *vs.* 23.5%]). The total sterol content, however, was considerably greater in the lipid fraction of *L. angustifolius* (1175 *vs.* 346 mg/100 g oil). This is a much higher sterol value than that in crops usually grown for this purpose, indicating possible scope for use in the cosmetics and pharmacological industries. The lipid composition of *L. albus* offered greater potential for use in the food processing industry.

The protein cake obtained from dehulled seeds had a lower crude fibre content (3.4 *vs.* 5.1% crude fibres) and was richer in protein (52 *vs.* 48%) than the cake obtained from whole seeds. There was no significant difference in the *in vitro* degradability kinetics of the dry matter between the two types of cake. The oil extraction process did not reduce the rumen degradability (> 80%) compared with whole seeds. For dairy cattle, the net energy content of the cake made from whole seeds and from dehulled seeds was 7% and 3% lower, respectively, than that of the whole seeds. Lupin cake is therefore attractive as animal feed in terms of its total protein and net energy content, despite its high rumen degradability.

Introduction

Lupin is cultivated mainly for its grains which are marketed as dry products, usually called pulses. It is a minor crop in Belgium, but is more common in Germany (58,000 T/year) and Poland (41,000 T/year). In 2005, Australia produced 1,079,000 T, representing 79% of the world production (UNIP, 2007). Lupin is an environment-friendly crop, adding diversity in crop rotation, with an ability to fix atmospheric nitrogen and improve soil structure. As a feedstuff, it also has the advantage of being exempt from genetically modified organisms and offers a complete traceability. Compared with pea and faba bean pulses, the main other grain legumes grown in most European countries, lupin pulses contain more protein (36%), more crude fibre (12%) and more lipids (10%) on a dry matter (DM) basis, but they have a lower starch content (8%).

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Several studies have investigated the nutritional value of lupin seed in animal diets. For dairy cows (Froidmont and Bartiaux-Thill, 2004), lupin appeared to be able to replace soybean meal entirely without affecting the milk production. It also had the advantage of improving the fatty acid pattern of the milk (for instance, it had a better ω6/ω3 ratio). In beef cattle feed, it was shown that lupin seed supplies a similar amount of digestible proteins to soybean meal when provided in a coarsely ground form (Froidmont et al., 2008). Incorporating lupin in pig feed should be limited because of the presence of α-galactosides, which are not degraded in the intestine and interfere with the digestibility of the other nutrients (Froidmont et al., 2005). In poultry diets, lupin could not replace more than half the soybean meal. For *Lupinus angustifolius*, this could be due to its high soluble fibre content, which increases the viscosity of the chyme and acts as an anti-nutritional factor (Froidmont et al., 2004).

Even if the results of these studies were promising, the main limitation to the expansion of lupin remains its profitability. Like other grain legumes, the economic return on a lupin crop varies greatly depending on the weather and soya prices, making it an unattractive choice for farmers despite its many advantages in crop husbandry terms (good first crop in a rotation, improves soil structure, fixes atmospheric N via the root nodules) (Jensen, 2002). The objective of this project was therefore to fractionate the seed and isolate the protein cake for animal feed from the remaining seed, which could be used in high value-added sectors, making the crop more profitable. The fibre and oil parts were characterized and new uses for these fractions were identified in terms of their content.

Materials and Methods

The first step involved extracting and characterizing the lipid fraction from two samples of lupin seed: *Lupinus angustifolius* (var. Boltensia) and *Lupinus albus* (var. Lublanc).

Because of the limited amount of oil in lupin seed, the use of a classical press for extracting was not possible, even at high temperatures. Two other methods of

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extraction were investigated. The first one was the supercritical CO_2 method, where CO_2 acts as a solvent at high pressure and moderate temperatures (Celabor SCRL, Herve, Belgium). The second one was the Soxhlet method, involving a solvent extraction (petroleum ether), as defined by the AOAC (960.39, 1990).

The fatty acid pattern of the oils was determined by GC-FID after methanol transesterification to form methyl esters (Norm: NF T 60-233). The sterol content of the oils was estimated after saponification, extraction of the insaponifiable part, separation of the components with thin layer chromatography, extraction of the sterols with chloroform, quantification by GC-FID and identification by GC-MS after trimethylsilylation (Lognay et al., 1993; Lognay et al., 1995).

The second step involved characterizing the protein fraction of four samples: lupin cake from whole seeds (*L. albus*, var. Lublanc); lupin cake from dehulled seeds (*L. albus*, var. Lublanc); *L. angustifolius* seeds (var. Boltensia); and *L. albus* seeds (var. Lublanc). The lupin cakes were obtained after extracting the oil with a solvent (Valagro S.A., La Rochelle, France – Patent FR2857825). The samples were ground through a 1-mm screen before conducting nitrogen (AOAC, 990.03, 1990), crude fibre (AOAC, 978.10, 1990) and lipid (AOAC, 960.39, 1990) analyses. The net energy for dairy cattle was evaluated on the basis of these analyses. In addition, because lupin is used mainly to feed cattle, the rumen DM degradability was determined *in vitro* with a specific incubator (ANKOM, DAISY II, Technology Corp. Macedon, NY), following the method described by Goering and Van Soest (1970).

Results and Discussion

The proportion of oil extracted from *L. albus* reached 4.75% and 4.78% DM using the Soxhlet and CO_2 supercritical methods, respectively. For *L. angustifolius*, these values were 7.51% and 8.05% DM, respectively. In the latter case, the yield from extraction was slightly higher with CO_2 supercritical, but the difference was too small to justify the additional cost incurred with this method.

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The chemical analyses were not influenced by the method of oil extraction. All the results presented in this paper are therefore mean values.

Table 1 presents the fatty acid pattern of lupin seeds. The amount of saturated fatty acids is similar for both samples. *L. angustifolius* contained a larger proportion of oleic acid (C18:0), whereas *L. albus* contained more polyunsaturated fatty acids, specifically linolenic acid (C18:3). This fatty acid would benefit human health by reducing the risk of cardiovascular diseases and cancer and stimulating the immune system (Herbaut, 2006). These authors found that the ω6/ω3 ratio of human food should be lower than 5, and this is largely the case for the oil extracted from *L. albus*. This suggests that *L. albus* has some advantages for use in the food industry and reinforces the potential of incorporating lupin in some foods, such as beverages, snacks, bread and pastas (Knauf et al., 2005), although usually no more than 10% of lupin is incorporated in human food.

Table 1. Fatty acid pattern of lupin seeds (% total fatty acids)

Fatty acids	Lupinus albus	Lupinus angustifolius
C14:0	0,3	0,4
C16:0	9,3	13,8
C18:0	0,5	5,5
C18:1	1,8	33,0
C18:2	53,2	36,6
C18:3	20,4	5,9
C20:0	9,8	0,7
C22:0	2,7	1,2
C24:0	2,0	2,9
Saturated fatty acids	**24,6**	**24,6**
Mono-unsaturated fatty acids	**1,8**	**33,0**
Poly-unsaturated fatty acids	**73,6**	**42,5**
ω6/ω3	**2,1**	**7,0**

Phytosterols are terpenes with a similar molecular structure to cholesterol. More than 100 molecules of phytosterol are known; they differ mainly in their lateral chain. Phytosterols are used to treat hypercholesterolemia (Kritchevsky and Chen, 2005) and prostatis hypertrophy (Carbin et al., 1990), and it is likely that they have some immunostimulating, anti-inflammatory and anticarcinogenic properties.

Table 2 presents the sterol contents of lupin seeds. In both samples, three phytosterols were present in significant amounts: campesterol, stigmasterol and beta-sitosterol. The analyses suggested that the content of total sterols was fivefold higher in *L. angustifolius* oil than in *L. albus* oil, and was higher than the content in crops more commonly used for sterol extraction. According to Soupas (2006), the phytosterol content of crude vegetable oils is between 70 and 1100 mg/100 g oil, with corn and rapeseed oils being the richest sources. Our results suggest that *L. angustifolius* oil could be interesting for the pharmaceutical and cosmetic industries.

Table 2. Sterol contents of lupin seeds (mg/100 g oil)

Sterol	Lupinus albus	Lupinus angustifolius
Cholesterol	0.9	5.4
Campesterol	93.8	334.5
Stigmasterol	36.1	96.4
Beta sitosterol	213.8	734.4
Delta-7-stigmasterol	1.2	2.6
Delta-7-avenasterol	0.4	1.6
Total	**346**	**1175**

Table 3 presents the chemical composition of the two types of lupin cake. Compared to whole seeds, the oil extraction from the cakes increased their protein content by more than 45%, reaching a similar level to that of soybean meal. This increase was due not only to the oil extraction, but also to the lower fibre content in the cakes. We know that lupin is rich in soluble fibres (Bach Knudsen and Gonzalez, 2004), such as pectins, that would have been washed

out during the oil extraction process. No clear hypothesis was found to explain the lower level of insoluble fibres in the cakes compared with the seeds, but a similar difference was noted between soya seed and some soybean meals by Sauvant et al. (2002). For dairy cattle, the net energy content of the cakes made from whole seeds and from dehulled seeds was 7% and 3% lower, respectively, than that of the whole seeds. The results also suggest that dehulling the seeds before oil extraction did not influence the chemical properties of the cakes very much.

Table 3. Chemical composition of whole seeds and lupin cakes (% DM)

	Lupinus albus	*Lupinus angustifolius*	Whole seed lupin cake	Dehulled lupin cake
Proteins	33	33	48	52
Crude fibres	16	15	5.1	3.4
NDF	24	26	9.3	7.6
ADF	21	22	9.5	5.1
Lipids	8.5	4.8	≤ 1	≤ 1
Net energy (kcal/kg)	2475	2409	2294	2376

NDF: Neutral Detergent Fibres, ADF: Acid Detergent Fibres

The DM degradability of lupin cakes was similar to that of whole seeds (> 80%), suggesting that the oil extraction process did not provide protection against microbial fermentation. Despite its high rumen degradability, lupin cake appeared as an attractive cattle feed due to its high protein and net energy contents.

Conclusions

Our study showed that the potential use of lupin oil depends on the lupin species. The fatty acids pattern in *L. albus* offers some advantages in terms of human health and would be interesting for the food sector industries, whereas the high phytosterol content of *L. angustifolius* oil offers new possibilities in the high value-added sectors, such as the pharmacological industry (non-food sector). Despite its high rumen degradability, the lupin protein cake appeared to

be good for cattle feed (feed sector) because of its high protein and net energy content. It would be interesting to separate the fibre from the protein part, to characterize this fraction more precisely and to present the results to the industry. The fractionation of plant products, with a view to finding specific uses depending on the fractions' physicochemical properties, could revive interest in minor crops and contribute to greater diversity in our agriculture.

Acknowledgements

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DATA COLLECTING METHODS REGARDING THE PHYTOSANITARY CONDITION OF AGRICULTURAL PLANTS IN POLAND

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Abstract

The information about the most important agrophages (pests and diseases) and their various tendencies in time is very crucial to provide adequate crop plant protection.

Every year during vegetation season, detailed observations are carried out according to methods issued by the Department of Methods of Forecasting and Pest Registration from Plant Protection Institute. In Methods (4 volumes) - "Prognosis, Signalization and Registration Instruction for Plant Health and Food Security Inspection" diseases/pests descriptions, observation methods, harmfulness evaluation methods (time, development stage, number and percentage) and other are explained.

The information regarding agricultural plants phytosanitary condition is sent to the Plant Protection Institute, where the Agrophages Data Base is updated and the "Phytosanitary Condition of Agricultural Plants with Prognosis in the Next Year" issue is published every year.

Introduction

In Poland, first institution collecting information about agricultural and forest plants pests and diseases occurrence was the Institute of Agriculture stated in

1816. In 1953 Plant Protection Institute (PPI) was established. The Institute was organized as a consequence of first Colorado leaf beetle (*Leptinotarsa decemlineata*) appearance in Poland in 1946 and its first significant yield looses in 1950.

One of the first Departments at PPI was Department of Methods of Forecasting and Pest Registration. In the initial period of the Department activity, data concerned on agrophages occurrence were based on field observations done by individual farmers. Later, the system of cooperation between Department and Plant Health and Seed Inspection Service (governmental body) was created. Thanks to such cooperation we have knowledge about changes in agrophages occurrence, appearance and harmfulness in different regions in Poland. Nowadays pests such as aphids (*Rhopalosiphum padi, Sitobion avenae*) and cereal leaf beetles (*Oulema* spp.) cause most of the damages in cereals. Back in the 70-thies gout fly (*Chlorops pumilionis*) and leaf hoppers (*Cicadellidae*) were the most harmful pests in cereal production. There are some pests (e.g. cutworms - *Noctuinae*) which increase considerably in certain period of time.

Materials and Methods

Every year during vegetation season, detailed observations are carried out according to Methods provided by the Plant Protection Institute from Department of Methods of Forecasting and Pest Registration. In methods (4 volumes) "Prognosis, Signalization and Registration Instruction for Plant Health and Food Security Inspection" (*Węgorek et al., 1976, Węgorek et al., 1982, Pruszyński et al., 1993, Walczak et al 1998*) diseases and pests descriptions, observation methods, harmfulness evaluation methods (time, development stage, number and percentage) and other are explained. First Methods were published in the seventies and are constantly updated and improved. In order to gain the

necessary information and work out the phytosanitary condition of agricultural plants, we need systematic field observations and field monitoring. Observations must be done once, during vegetation season in correct time for every pest or disease (Table 1) in concrete developmental host plant stage. Agrophages harmfulness is shown as a percentage of infected or damaged plants, leafs, roots, siliques etc.

Table 1
Methods information for some agrophags harmfulness evaluation observations.

Disease / Pest	Host plant	Observed plant organ	Plant development stage
Blumeria graminis powdery mildew	cereals	stem, leaves	heading, flowering
Phaeosphaera nodorum septoria leaf spot	cereals	ear	dough stage of grain
Oulema spp. cereal leaf beetle	cereals	stem, leaves	end of flowering / beginning of maturing
Rhopalosiphum padi cereal aphid	cereals	stem, leaves	beginning of heading
Leptosphaeria maculans dry-roy of cabbage	winter rape	leaves, base of stem	autumn: leaves development; spring: beginning of silique maturing
Meligethes aeneus rape blossom beetle	winter rape	blossom	end of flowering
Ceutorrhynhus quadridens cabbage seedstalk curculio	winter rape	stem	silique maturing
Phytophtora infestans potato blight	potato	leaves	seeds maturing
Leptinotarsa decemlineata colorado beetle	potato	leaves	flowering
Cercospora beticola cercospora leaf spot	sugar beet	leaves	end of interrows by leaves covering

Observations are provided on main agricultural plants (cereals, maize, oil-seed rapes, potatoes sugar beets, papilionaceous plants, vegetables – tomato, cucumber, onion, cabbage, carrot and fruit plants – apples, cherries, plums, strawberries) and the list of monitored agrophages is updated every year.

The results of field observations are sent back to the Plant Protection Institute (Department of Methods of Forecasting and Pest Registration) were data are worked out and transformed into tables, maps and graphs.

Research Results

Information regarding agricultural plants phytosanitary condition is the base of issue "Phytosanitary Condition of Agricultural Plants with Prognosis in the Next Year" which is published every year. The issue shows the most important agrophages occurrence changes in time and regions and some forecasting suggestions to the next vegetation season.

Conclusions

Many years data base located at Plant Protection Institute concerned on agrophages (pest/diseases) harmfulness and incidence is the only of that kind in Poland. From this data base we can observed:
- Pests and diseases economic importance differ in different regions,
- Changes in economic importance of agricultural plants agrophages (thanks to many years data registration),
- In case of pests which occur in Poland suddenly we can observe their spreading in country (Figure 1) (*Walczak, 1990*).

Figure 1: Saddle gall-migde (*Haplodiplosis equestris* Wagn.) spreading in Poland.

One of the most important advantages of such data base is the possibility to state long-term prognosis. On the base on many years field observation results

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we can predict pest/disease occurrence and regions where agrophage can cause significant infections.

Information on the most important agrophages (pests and diseases) and various tendencies in time is very crucial to provide adequate crop plant protection, and support the idea of sustainable farming.

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EVALUATION OF DIFFERENT WIND TUNNEL PROTOCOLS FOR SPRAY DRIFT RISK ASSESSMENT

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Abstract

46 Wind tunnel measurements were carried out to measure airborne and fallout spray volumes for 10 different spray nozzles. Based on these measurements, drift potential reduction percentages (DPRP), expressing the percentage reduction of the drift potential compared with the reference spraying, were calculated following three different approaches ($DPRP_{V1}$, $DPRP_{V2}$ & $DPRP_H$).

The results showed the expected fallout and airborne spray profiles and the effect of nozzle type and size on DPRP values was demonstrated. For the standard flat fan nozzles, $DPRP_{V1}$ values were the highest followed by $DPRP_{V2}$ and $DPRP_H$ while for the low-drift nozzles opposite results were found. For the air inclusion nozzles, there was a relatively good agreement between $DPRP_{V1}$, $DPRP_{V2}$ and $DPRP_H$ values. All of this is important in the interpretation of wind tunnel data for different nozzle types and sampling methodologies.

A comparison was made between the results obtained from the wind tunnel measurements and the results from direct field drift measurements. Results showed that in the wind tunnel, driftability experiments can be made with

different spraying systems under directly comparable and repeatable conditions and this methodology is well suited to permit relative studies of drift risk. The wind tunnel approach, calculating the surface under the measured fallout deposit curve (DPRP$_H$), was best suited to represent real near-field sedimenting drift characteristics.

Introduction

Within the framework of a research project about spray drift from field sprayers, different spray application techniques have been tested using three different risk assessment means which are PDPA laser measurements (Nuyttens et al., 2006, 2007 a), wind tunnel measurements (Nuyttens, 2007) and field drift measurements (Nuyttens et al., 2007 b). These experiments have been used to perform a spray drift risk assessment (De Schampheleire et al., 2006) and to develop a CFD drift model for field sprayers (Baetens et al., 2007). This paper presents results from the wind tunnel measurements following three different approaches. The results obtained with this indirect drift assessment mean are compared with the ones from the field measurements to evaluate its potential for drift risk assessment.

Materials and Methods

Spray application techniques
An overview of the tested spray nozzles at a pressure of 3.0 bar and a height of 0.5 m is presented in Table 1. The reference spraying is defined as a Hardi ISO F 110 03 standard flat fan nozzle. This reference spraying is used for a comparative assessment of the different spray applications.

Nozzle	Flow rate (l min^{-1})	Nozzle	Flow rate (l min^{-1})
Hardi ISO F 110 02	0.80	Hardi ISO LD 110 03	1.20
Hardi ISO F 110 03[a]	1.20	Hardi ISO LD 110 04	1.60
Hardi ISO F 110 04	1.60	Hardi ISO Injet 110 02	0.80
Hardi ISO F 110 06	2.40	Hardi ISO Injet 110 03	1.20
Hardi ISO LD 110 02	0.80	Hardi ISO Injet 110 04	1.60

[a] Reference spray application

Wind tunnel measurements

46 wind tunnel experiments were carried out in the Silsoe Research Institute (SRI) wind tunnel facility. Measuring set-up and protocol have been described by Nuyttens (2007). An overview is presented in Figure 1. Single and static nozzles at a height of 0.50 m were exposed to a wind tunnel air speed from 2 m s^{-1}.

Exposure time was 10 s. Drift risk was assessed by measuring the quantities of spray deposited downwind of the nozzle on horizontal 2 mm diameter polythene lines in a vertical ($V_1 \rightarrow V_5$) and a horizontal array ($H_1 \rightarrow H_6$) using a water-soluble fluorescent tracer (sodium fluorescein at 0.02%)(Fig. 1). Values for deposits have been normalised to a common rate of liquid emission by the nozzle and are expressed as the volume of spray recovered from the lines (in μl) for every litre of spray solution that has been emitted by the nozzle. Drift potential values of the different spray nozzles are compared with the equivalent results obtained from the reference spraying by calculating their drift potential reduction percentage (DPRP, %) following three different approaches. DPRP$_{V1}$ was calculated based on the first moment of the airborne deposit profiles, DPRP$_{V2}$ based on numerical integration of the airborne deposit curves and DPRP$_H$ based on numerical integration of the fallout deposit curves.
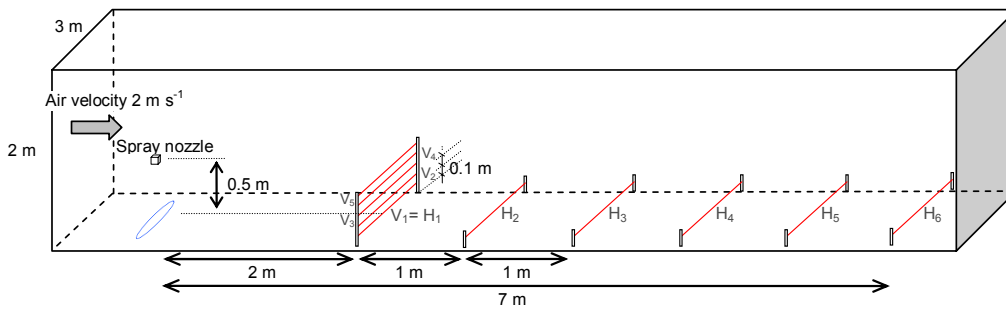
Figure 1. Wind tunnel measuring setup with the different collector lines (airborne deposits: $V_1 \rightarrow V_5$ and fallout deposits: $H_1 \rightarrow H_6$)

Field drift experiments

Field drift measurements have been carried out according to ISO 22866. The measuring set-up, protocol and the data processing are described in detail by Nuyttens et al. (2007 b). The total drift reduction potential (DRP_t, %) of the different nozzles (Table 1) was calculated by comparing the surface under the measured drift curve with the surface under the predicted drift curve of the reference spraying, for the same weather conditions. DRP_t values were compared with DPRP values to evaluate the potential of the different wind tunnel protocols for spray drift risk assessment. All field drift experiments were performed on a flat meadow at a driving speed of 8 km h^{-1} and with a boom height and nozzle distance of 0.50 m.

Research Results

DPRP values based on the three different approaches ($DPRP_{V1}$, $DPRP_{V2}$ and $DPRP_H$) are presented in Fig. 2 together with the corresponding 95% confidence intervals. In Fig. 3, $DPRP_{V1}$, $DPRP_{V2}$ and $DPRP_H$ values resulting from the wind tunnel measurements are compared with the corresponding DRP_t values (Nuyttens et al., 2007 a) from the field drift experiments for the different nozzle types. The simple linear regressions and their corresponding R^2 values are presented.

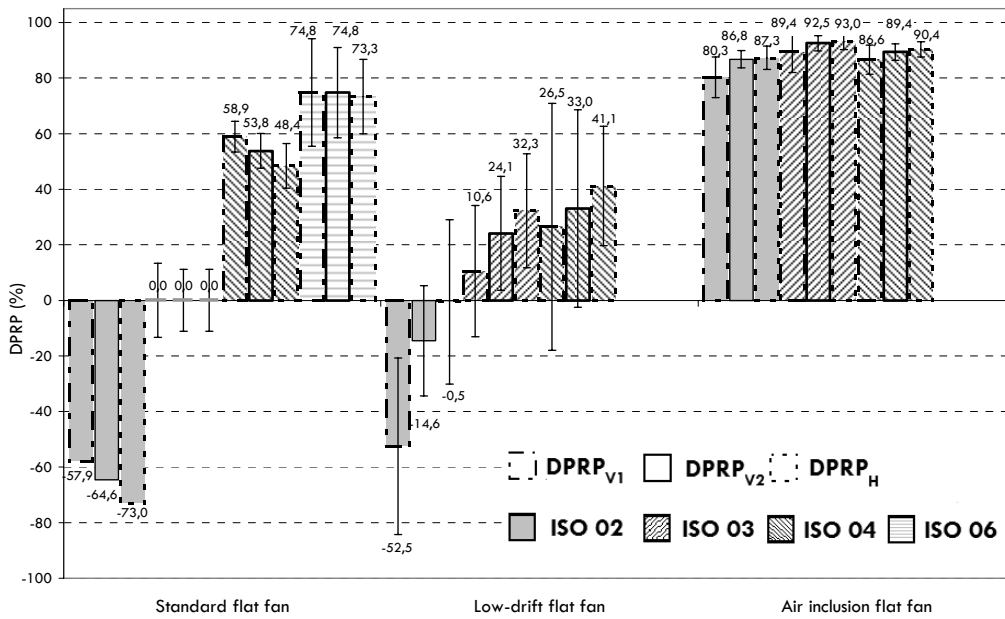**Figure 2. DPRP_V1, DPRP_V2 and DPRP_H values and their 95% confidence intervals for the different nozzle types compared to the reference (Hardi ISO F 110 03 standard flat fan)**
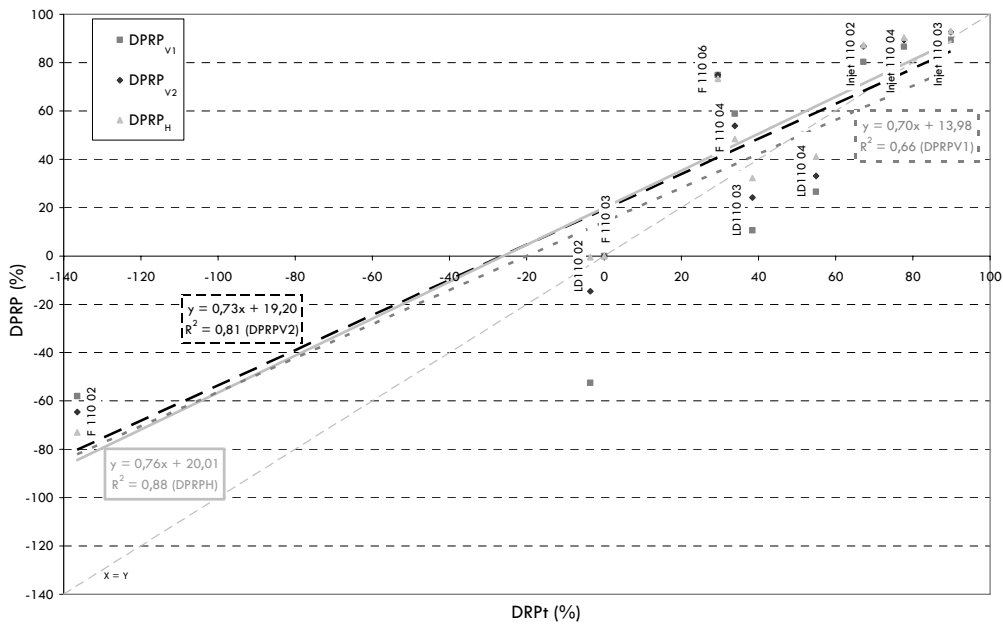

Figure 3. Comparison between DPRP and DRP_t values for different Hardi ISO nozzle types

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Discussion and conclusions

It is clear that the nozzle type (standard, low-drift and air inclusion flat fan) has an important influence on the drift potential (Fig. 2). For one and the same nozzle size, DPRP values of the air inclusion nozzles are always higher than DPRP values of the standard flat fan and the low-drift flat fan nozzles and differences are statistically significant. In case of ISO 02 and ISO 03 nozzle sizes, low-drift nozzles have higher DPRP values compared with standard flat fan nozzles. The effect of nozzle type is most important for smaller nozzle sizes.

Besides nozzle type, the size of the nozzle is also related to the drift potential. In general, for the standard flat fan nozzles and the low-drift nozzles, DPRP values increase with increasing nozzle sizes. For the air inclusion nozzles, the effect of nozzle size on DPRP values is less clear and in general statistically not significant.

Comparing results conducted by the three different wind tunnel approaches namely, $DPRP_{V1}$, $DPRP_{V2}$ and $DPRP_H$, some interesting conclusions can be drawn (Fig. 2). For the standard flat fan nozzles, $DPRP_{V1}$ values were the highest followed by $DPRP_{V2}$ and $DPRP_H$. This means that by comparing with the reference spraying, airborne deposits are relatively lower than fallout deposits.

For the low-drift nozzles opposite results were found. $DPRP_H$ values were the highest followed by $DPRP_{V2}$ and $DPRP_{V1}$. For the air inclusion nozzles, a relatively good agreement between $DPRP_{V1}$, $DPRP_{V2}$ and $DPRP_H$ values was found. All of this is important in the interpretation of wind tunnel data for different nozzle types and sampling methodologies.

From Fig. 3, it is clear that there is a fairly good linear relation between DRP_t and DPRP values for the different spray nozzles with R^2 values of 0.66, 0.81 and 0.88, respectively for, $DPRP_{V1}$, $DPRP_{V2}$ and $DPRP_H$. Hence, from the three wind tunnel approaches, the approach calculating the surface under the measured fallout deposit curve is best suited to represent real near-field sedimenting drift characteristics. Despite the fairly good correlation between DRP_t and DPRP values, there are some important discrepancies which are

important to keep in mind when interpreting wind tunnel results. The deviation of the first-order regression lines from the bisector is mainly caused by the leverage effect and the results of the F 110 02 nozzle with its relatively high DPRP values compared with the corresponding DRP_t value of -136.5%. Among the other standard flat fan nozzles, a considerable and statistically significant difference between DRP_t and DPRP values is also observed for the F 110 06 nozzle. Although for the ISO 03 and ISO 04 standard flat fan nozzles, there is a good agreement between DRP_t and DPRP values, it can be seen that DPRP values are generally higher than DRP_t values for the standard flat fan nozzles.

Knowing that for the standard flat fan nozzles, $DPRP_{V1}$ values were the highest followed by $DPRP_{V2}$ and $DPRP_H$, it is clear that $DPRP_H$ corresponds best with DRP_t results. For the different sizes of low-drift nozzles, a good agreement between wind tunnel and field drift results is found. In contrast with the standard flat fan nozzles, DPRP values are generally lower than DRP_t values. Because for this nozzle type, $DPRP_{V1}$ values were the lowest followed by $DPRP_{V2}$ and $DPRP_H$, $DPRP_H$ again corresponds best with DRP_t.

In conclusion, results showed that in the wind tunnel, driftability experiments can be made with different spraying systems under directly comparable and repeatable conditions and this methodology is well suited to permit relative studies of drift risk. The wind tunnel approach, calculating the surface under the measured fallout deposit curve ($DPRP_H$), was best suited to represent real near-field sedimenting drift characteristics. Wind tunnel experiments permit a drift potential to be calculated to assess relative drift risk but it is difficult to investigate effects like driving speed, air assistance and weather conditions where direct drift measurements are necessary. Moreover, field research is appropriate for obtaining realistic absolute estimates of drift under a range of working conditions but it is time-consuming and expensive.

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OPTIMIZATION OF OPERATIONAL PARAMETERS AND FIRST ASSESSMENT OF NEW TUNNEL SPRAYER

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Abstract

A new prototype of air-assisted tunnel sprayer for trellised grapevines was developed by the University of Udine and built by Agricolmeccanica s.r.l. The sprayer was based on the principle of filtering the excess spray volume through a lamellae separator. Before practical evaluation in the field, the prototype was tested under static conditions, in order to find an optimum setting of the main operational parameters. The best sprayer setup of obtained with 0.50 m distance between the shields, and a 2.40 m^3/s air flow rate, allowed the recovery efficiency to reach 95 % of the liquid sprayed in the stationary mode. The sprayer was used for spray application in a vineyard during the 2007 season, showing good reliability and work capacity. The percentage of liquid recycled was maximum for the treatment made early in the season (77% on 3 April) and minimum for the last treatments before harvesting (34% on 11 July), depending on the leaf area of the crop and other factors.

Introduction

Tunnel (recycling) sprayers have long been recognised as an important tool to reduce drift losses (by more than 90%, according to Bäcker, 1993). Depending on the crop and the growth stage, tunnel sprayers may recycle 15% to 60% of the spray volume (Siegfried and Holliger, 1996), thus enabling the farmers to control pests even at reduced PPP dose rates. Nevertheless, the introduction of

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Figure 1. The prototype tunnel sprayer during application in the vineyard.

tunnel sprayers in Italian vine-growing farms has been hindered by high machine cost, low working speed, and unsatisfactory quality of distribution. In fact, many models have led to insufficient spray penetration into the canopy and low deposition on leaf undersides. This may be critical for controlling diseases such as downy mildew (Viret *et al.*, 2003), particularly under environmental conditions typical of the N.E. of Italy. In order to answer the specific needs of Italian viticulture, a new prototype of air-assisted tunnel sprayer has been developed in a joint project conducted by the University of Udine and Agricolmeccanica s.r.l.. Initial tests were performed to gather baseline information on machine performance, and more particularly:

- to analyse the effects of the main operational parameters on spray recovery rate under static conditions;
- to test the sprayer in the vineyard, under actual field conditions, during the 2007 growing season, and to analyse the spray recovery rate at different growth stages and leaf densities of the vines.

Materials and Methods

The prototype was a two-row, tractor mounted sprayer (figure 1). Each tunnel consisted of a couple of symmetrical shields. The distance between the shields

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and between the two tunnels could be adjusted depending on inter-row distance (1.80 to 3.60 m) and canopy width (up to 1.0 m). Each shield supported: an axial-flow fan, placed above the tunnel; a vertical air boom with six air jets that could be rotated both horizontally and vertically; a vertical spray boom with six nozzles; a spray capture panel designed to recover the excess spray not deposited onto the canopy, and to discharge the air flow to the outside; a recovery basin, connected to the recycling system of the sprayer, to convey the recovered liquid back to the tank after being filtered.

The performance of various configurations of the sprayer was evaluated on the basis of spray recovery trials, performed with water only under static conditions, and without vines. The sprayer was fitted with 12 Albuz ATR brown hollow cone nozzles (Very Fine BCPC spray quality at 10 bar), and the total flow rate was 7.92 l/min. The recovery rate was calculated as the ratio of the volume of spray collected from the tube of the recycling system over the spray volume applied.

Four different tests were performed. Test No. 1 was a factorial experiment, in which the following settings were compared: three tunnel opening (0.50 m, 0.75 m and 1.00 m); three outlet anglings (both air booms symmetrically rotated towards the centre of the tunnel by 10°, 20° or 30°), and three fan speeds (36.1 rev/s, 46.8 rev/s and 52.4 rev/s; corresponding to air flow rates of 1.46 m^3/s, 2.05 m^3/s, and 2.40 m^3/s, respectively). In test No. 2, the effect of different outlet orientations (10°, 15°, 20°, 25° and 30°) was further analysed at medium fan speed and three tunnel openings. Tests No. 3 and No. 4 were conducted to assess the potential advantages of the prototype, relative to different possible configurations, such as: tunnel sprayer without air-assistance, or with air-assistance, but with full walls and no air/droplet separators. In test No. 3, the fans were shut off, and this adjustment compared with the medium fan speed and three tunnel openings, in order to assess the effect of air-assistance on the spray recovery rate. Finally, in test No. 4 the separator panels were made ineffective by covering their inner or outer side with plastic foils, so as to simulate a tunnel sprayer with full containment walls. Further tests were performed with the tunnel sprayer in motion at 6.2 km/h forward speed. Tunnel opening was adjusted at 0.50 m, and the fan speed of 52.4 rev/s.

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Outlet orientation was initially set at 25° backwards (front boom) and 25° forward (rear boom). Additional runs were made after rotating either the front or rear outlets, in steps of 5°, and repeating the procedure until no further improvement in the spray recovery rate was recorded.

During 2007, the tunnel sprayer was used for six treatments against powdery mildew and downy mildew in a commercial vineyard estate, located in San Martino (N.E. Italy). The vineyard (cv: Merlot) was trained to a spur-pruned low cordon (planting distances: 2.4 m x 0.8 m). Standard canopy management was performed, which helped to limit the canopy width to 0.5 m or less at all growth stages. After each application, six vines were randomly chosen in the vineyard for the assessment of the leaf area index (LAI).

Table 1. Static test No. 1: effect of tunnel opening, fan speed and outlet orientation on spray recovery rate.

Recovery rate, %									
Tunnel opening, m	Outlet orientation, degrees								
	10°			20°			30°		
	Fan speed, rev/s								
	36.2	46.8	52.4	36.2	46.8	52.4	36.2	46.8	52.4
0.50	88.1	89.5	85.7	93.9	93.9	95.1	87.8	91.4	93.5
0.75	81.7	85.9	85.9	89.3	92.6	93.5	86.2	88.9	86.8
1.00	81,0	81,0	79,2	85,7	84,8	84,8	81,9	83,1	84,5

Research Results

The maximum recovery rate in static test No. 1 (95.1%, Table 1) was recorded after adjusting the distance between the tunnel's walls at the minimum, 0.50 m, the outlet orientation at 20°, and the fan speed at the maximum. The reduction in the recovery rate at increasing distances between the tunnel's walls was largely expected. However, this effect was clearly visible only at the 1.00 m opening. The spray recovery rate was little affected by the air flow rate adjustments. This was indeed a good result, since it suggested that it would be possible, during spray application in the vineyard, to choose the correct air flow

rate in order to obtain sufficient penetration into the vine canopy, without affecting the spray recovering and recycling potential of the sprayer. Also the effects of different outlet orientations were comparably small. In general, the best angling of the air outlets was 20°.

Test no. 2 allowed a more complete analysis of the effects of outlet orientation. The test has evidenced that the best angling of outlets for each tunnel opening and was 15°, 20° or 25° for openings of 1.00 m, 0.75 m and 0.50 m, respectively. This was consistent with the fact that, for a given angle of inclination, the air flow would impact the separator panel in slightly different points, depending on the distance between the shields. The best setup was always obtained when the air jets were orientated towards the middle of the spray separator panel.

Table 2. Right: static test No. 3: no fan versus medium fan speed (46.8 rev/s). Left static test No. 4: effect of separator panel covering.

Static test No. 3			Static test No. 4				
	Recovery rate, %				Recovery rate, %		
Tunnel opening, m	No fan	Medium fan speed	Tunnel opening, m	Outlet orientation, degrees	panels covered at the inside	panels covered at the outside	panels not covered
0.50	74.6	94.2	0.50	25	77.7	79.9	93.3
0.75	71.7	92.5	0.75	20	70.6	72.0	92.1
1.00	61.8	84.7	1.00	15	60.6	62.1	86.3

Test No. 3 showed that air-assistance was important to improve the recovery rate. In the no-fan treatment, in fact, part of the droplets did not even have sufficient energy to reach the separator panel at the facing tunnel wall, and were mainly lost through the opening at the bottom of the tunnel. As a consequence, the recovery rate was decreased at 61.8% to 74.6%, depending on tunnel opening (Table 2, left). Test No. 4 showed that a similar reduction could be expected from a tunnel sprayer fitted with air-assistance and full containment walls (60.6% to 79.9%, Table 2, right).

Table 3. Dynamic tests: effect of outlet orientation.

Outlet orientation, degrees		test conditions	Recovery rate, %
front air boom (forwards)	rear air boom (backwards)		
25	25	static	95.0
25	25	dynamic, at 6.23 km/h forward speed	83.8
5	25		87.4
0	25		86.7
0	30		79.6

The dynamic tests showed that the orientation of the air outlets, and particularly the front ones, needed to be differently adjusted, in order to compensate for the effect of the additional flow of air, entering the tunnel from the front opening.

In fact, in stationary mode the maximum recovery rate (95.0%) was obtained with a symmetrical orientation of air booms angled at 25°, while in dynamical mode the maximum recovery rate (83.8%, Table 3) was obtained with 5° forwards for the front air boom and 25° backwards for the back one.

Table 4. Amount of spray recycled by the tunnel sprayer in 2.71 ha during 2007

Trial Date (2007)	LAI	Tunnel opening, m	Recovery rate, %	Open nozzles per side	Volume sprayed, l/ha	Nozzle type
3-April	0.00	0.60	77	3	319	ATR brown
3-May	0.33	0.55	40	2	219	ATR orange
9-May	0.53	0.60	47	3	323	ATR orange
21-May	0.46	0.60	47	3	323	ATR orange
31-May	0.61	0.60	50	4	444	ATR orange
8-June	0.96	0.65	40	5	555	ATR orange
11-July	1.79	0.65	34	6	433	ATR yellow

The recovery rate in the vineyard ranged from 77% before bud break to 34% at full foliage development (Table 4). This was expected, since the increase in the leaf area index (LAI) increased the fraction of spray retained by the canopy, and it also decreased the amount of spray that could be recovered by the tunnel sprayer. However, the recovery rate was relatively constant between May 3 and June 8 (40% to 50%, Table 4), despite an increase in the LAI by nearly three times (from 0.33 to 0.96).

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The work capacity was 2 ha/h with 22.5% of total time lost for turning manoeuvres and tank refilling.

Discussion and Conclusions

Under static conditions the percentage of liquid recycled was strongly influenced by the distance between the shields, while only slightly affected by the air flow rates. The best sprayer setup, obtained with a minimum distance from shields and maximum air flow rate gave a recovery efficiency around 95 %. Under dynamic conditions, the maximum spray recovery rate decreased, owing to the effect of incoming air flow. Adjusting the orientation of the air outlets to 5° backwards (front air boom) and 25° forward (rear boom) could partially compensate for this effect, resulting in a recovery rate of 87.4%. This suggested that the prototype could be possibly improved by increasing the air flow rate of the fans, or by using additional air jets to shield the front opening from the incoming air flux.

Under field conditions the tunnel sprayer showed a high percentage of liquid recycled (34% to 50%), and good reliability and work capacity.
These preliminary tests were also useful to set up the tunnel sprayer for further analyses, in order to assess the spray distribution over the foliage, penetration into the canopy and coverage of the under side of the leaves.

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IF 10 POINTS ARE NO LONGER SUFFICIENT – AN OBSERVATIONAL STUDY ON UDDER HEALTH AND MILK QUALITY RELATED FACTORS IN FLANDERS, BELGIUM

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Keywords : mastitis, dairy cattle, coagulase-negative staphylococci (CNS), teat apex condition

Introduction

In Flanders a shift of the distribution of mastitis pathogens towards coagulase-negative staphylococci (CNS) and coliforms in dairy cattle has been observed in recent years (Piepers *et al.*, 2007; MCC, 2007). This is in agreement with the observations of Smith en Hogan (2001). Despite the implementation of the 10 point mastitis control program (NMC, 2008) in most Flemish dairy herds, this shift may be the cause of the recent problems of increasing bulk milk somatic cell counts, decreasing milk quality or a combination of both problems (MCC, 2007). The objectives of this study are (1) the clarification of the complex relationships between different factors explaining mastitis status of cows and quarters, (2) the observation of the evolution of these relationships in time and (3) the optimisation of new research tools for these objectives.

Materials and Methods

Ten randomly selected dairy cows are monitored during a one year period on six Flemish dairy herds. For comparison, three farms with and three without specific coliform problems have been included in the study. Teat swabs, quarter milk samples and environmental samples are collected monthly and cultured for presence of mastitis bacteria. Molecular identification and typing techniques are used to identify CNS and to find the main sources of CNS infections. Also, risk factors for intramammary infection are being studied at different levels. E.g. monthly climate variations (temperature, humidity, gas concentrations, dust) are investigated with innovative techniques. At the cow level, zootechnical information is complemented with records of cleanliness, body condition, gait and milking characteristics. At the quarter level, the conformation, teat apex condition and cleanliness of the teats are observed with an image processing program developed in Halcon.

Research Results

All measurement methods have been optimised for routine detection and have been proven to be robust enough for monthly monitoring. Further results are not available yet.

Discussion and Conclusions

The monthly observations will contribute to the clarification of the complex relationships between different factors explaining the mastitis status of cows and quarters and their evolutions in time.

Acknowledgements

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ENVIRONMENT

PESTEAUX: A PROJECT FOR BUILDING GIS-BASED TOOL FOR THE ASSESSMENT OF WATER POLLUTION RISKS AT LOCAL SCALE DUE TO PESTICIDES

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Keywords: Pesticide, vulnerability, surface and ground waters pollution, risks assessment, modelling, GIS

Abstract

Diffuse pollution of water resources due to pesticides uses is a major environmental issue in the European Union, regulated by specific legislations: the Water Framework Directive (Directive 2000/60/EC) and the Thematic Strategy on the Sustainable Use of Pesticides. Solving this environmental problem requires methods and tools for spatial risk analysis, notably at a local scale (agricultural parcel level). This paper presents the first developments of a decision support system aiming to assess surface and ground waters pollution risks due to pesticides uses, based on a Geographic Information System (GIS). Different factors affecting pesticide environmental propagation are taken into account, as for example land use, pesticides properties and application modalities, environment characteristics (soil properties, topography, climate, …) as well as surface and ground waters characteristics. A pesticide emission model is used to assess pesticide leaching or runoff to water resources. The reference scale for risks assessment is the agricultural parcel. The quality of the results obtained will be assessed by comparison with existing water monitoring data and related studies.

Introduction

Nowadays, pesticides pollution of drinking water in reserves and aquatic systems is a key issue of the European Policy with the implementation of the Water Framework Directive (Directive 2000/60/EC) and the Thematic Strategy on the Sustainable Use of Pesticides. According to these legislations, Member States are supposed to take measures to limit environmental and toxicological effects caused by pesticides uses[2].

This project initiated by the Walloon Agricultural Research Centre (CRA-W) aimed at implementing a decision support system based on a Geographic Information System (GIS) to assess diffuse (non-point sources) pollution risks of surface and ground water resources by pesticides.

Contrary to most of the existing tools usually working at a wider scale (catchment or regional level), the innovative aspect of the approach is the possibility to generate pollution risks maps at a local scale (agricultural parcel level). Another originality of the tool is the possibility to estimate pollution risks by taking into account worst-case scenarios and highlight sensitive areas.
This paper describes the methodology followed for the development of the pesticide pollution risks assessment tool.

Material and Methods

Water pollution risk assessment
Pollution risks assessment depends on three main factors: (1) the pollution source, (2) the environment through which transits the pollutant, and which is also the vector of transmission and dispersion, and (3) the pollutant receiver(s) i.e. the surface and ground water resources in our study. Figure 1 gives a schematic overview of the main factors involved.

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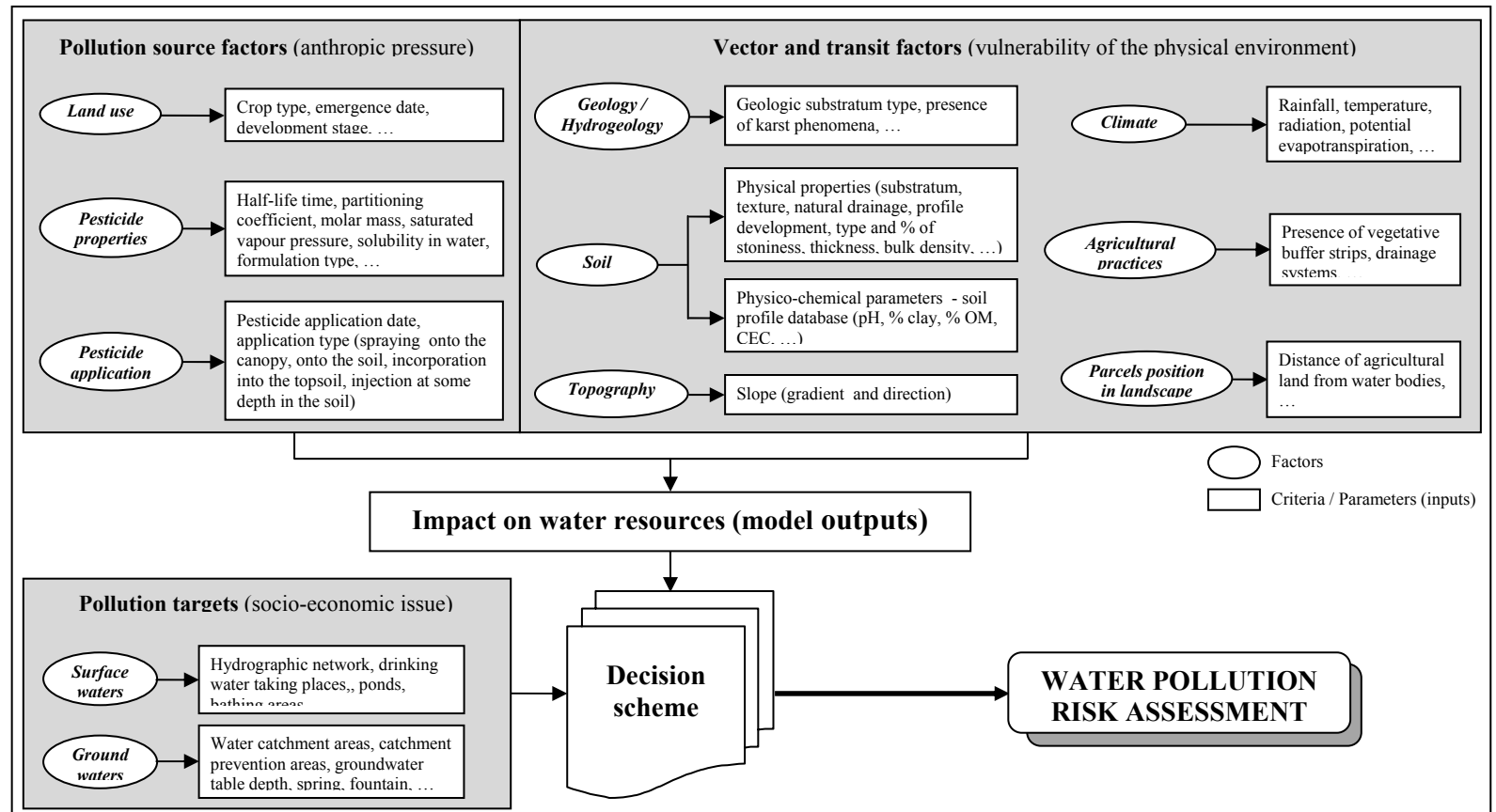
**Figure 1 – Schematic overview of the pollution risks assessment**

Pollution source factors

In our study, only diffuse pollution is considered and is characterized by parameters related to land use (crop type, …), pesticide properties (particularly half-life time, partitioning coefficient, sorption coefficient, solubility in water, …) and pesticide application modalities (date, type, quantity).

Vector and transit factors

Pesticides are mainly propagated by water, through runoff to surface waters and infiltration into the soil to groundwaters. Pesticides transfer from the soil to water depends on several parameters: (i) environmental characteristics (geology and hydrogeology, soil, topography and climate), determining the vulnerability to pollutants penetration and migration; (ii) agricultural practices, such as efficiency and accuracy of sprayer, protection means (vegetative buffer strips, …), a way to limit pesticide transfer into water, or drainage systems, which can have opposite effects by draining pesticides rapidly into surface waters; and (iii) agricultural parcels position in landscape with regard to water bodies.

One of the core data sources of the local risks assessment is the Digital Soil Map of Wallonia (Fig. 2), implemented from the Belgian "paper" Soil map at the scale of 1/20,000, providing detailed geomorphopedologic information at parcel level.
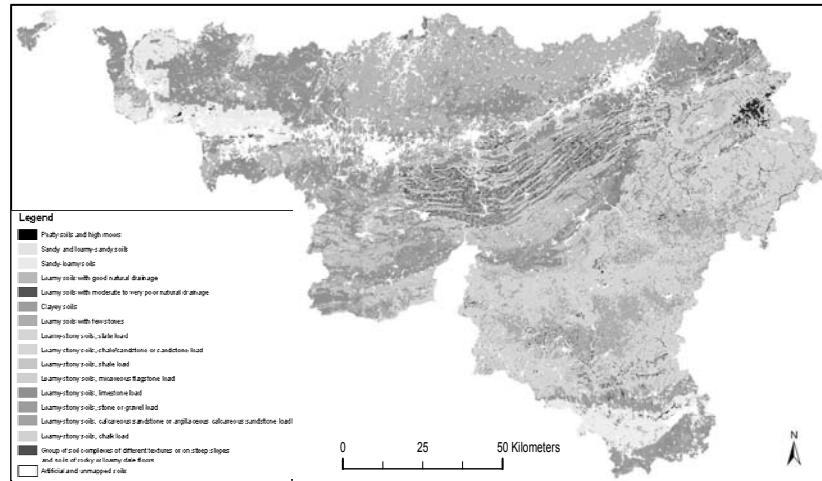
Pollution targets

Pollution targets are, in the framework of this study, water resources (surface and ground waters). Thus, pollution risks will be assessed for both surface and groundwaters which implies to consider spatial and monitoring databases for these two water resources. For example the hydrographical network or ponds will be taken into account for surface waters and water catchments for groundwaters.

Modeling tool

Modeling is more and more used for pesticides runoff and leaching assessment and therefore to assess the risks to pollutants propagation. In our study we have selected, on the basis of a state-of-the-art, a pesticide leaching to groundwater and drainage/runoff to surface water model named GeoPEARL (Tiktak *et al.*, 2003). GeoPEARL consists in a GIS coupled to a one-dimensional, dynamic and multi-layered model (PEARL: Pesticide Emission Assessment at Regional and Local scales) of the fate of pesticides and relevant transformation products in the soil-plant-atmosphere system. Model inputs are mainly extracted from the existing databases of pesticide properties (source) and environmental characteristics (vector/transit). Parameters not directly available in existing databases, such as bulk density, hydraulic conductivity, … will be derived from pedotransfers functions. Relevant parameters, such as karst phenomena, proximity of agricultural parcels in comparison to surface waters, … not taken into account by the model, will be considered in the decision scheme.

Validation of results

Validation will be conducted in pilot areas, where monitoring data on surface and groundwaters are available. The first selected pilot area is the Molignée catchment (Fig. 3), in the Belgian Condroz region. Molignée catchment is a geomorphopedological contrasted area. Several relevant hydrogeologic, pedologic and hydrologic studies (DGRNE, 2000) have been conducted in this area. Results of these studies will be used to validate the developed pollution risks assessment system.
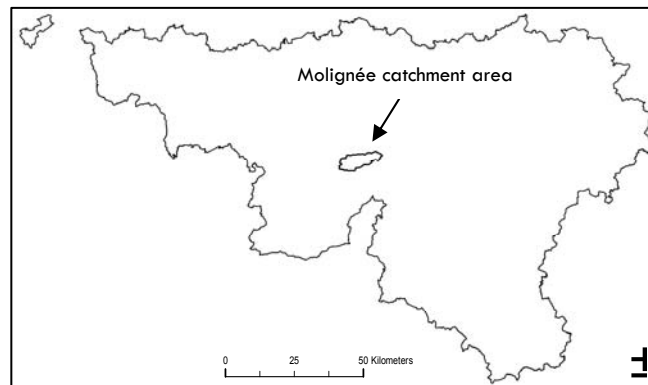
Figure 3 – Location of the pilot area in Walloon region (Belgium).

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PLANT PROTECTION PRODUCT-SAVING EQUIPMENT

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Abstract

There are indications that at least to some extent, the quantity of plant protection products used exceeds the required amount.

Intensified efforts are therefore required for further reducing the risks arising from the application of plant protection products, limiting application quantities strictly to the required amount, and making the use of plant protection products more transparent.

There are many measures intended to contribute to limiting the application of plant protection products in particular to the required amount, to a greater extent than before, so that the unnecessary application of these plant protection products is avoided and the use of non-chemical plant protection measures is encourage.

Through technical measures, not only can drift resulting from the application of plant protection products be reduced, but also considerable amounts of the plant protection products themselves. Primarily, recycling equipment for viticulture and fruit growing and sensor-controlled sprayers with gap-detecting systems , amongst other methods, must be mentioned.

The Institute for Application Techniques (AT) of the Julius Kühn-Institut (JKI) in Braunschweig, has developed a test procedure which is defined in a JKI guideline. On this basis, the saving potential of the most diverse equipment developments with regard to the application of plant protection products can be determined reliably and is traceable. Following the submission of corresponding trial results by the applicant and positive testing by the AT/JKI, the equipment is registered in the section 'saving' of the index of loss reducing equipment.

Equipment tests for saving with regard to the amount of plant protection products applied began in 2006.

In 2007, 4 pieces of equipment could be registered in the saving section for plant protection products, in the index stated above, on the basis of the results available from the tests carried out in the field. This means that on the basis of an established testing method, evidence is available of savings in the use of plant protection products of more than 50 %.

This new test procedure is also a contribution to the program for reductions in the use of plant protection products.

Introduction

To be able to produce high quality food in sufficient quantities, considerable amounts of plant protection products are used.

Despite the existing dense of statutory and other regulations for plant protection products and plant protection equipment, there is a constant demand for limiting the extent of plant protection product measures even further and for limiting the plant protection products used to the minimum extent considered necessary.

In order to achieve this target, all plant production disciplines, from research and industry to every day agricultural practice, have to be involved and make a contribution.
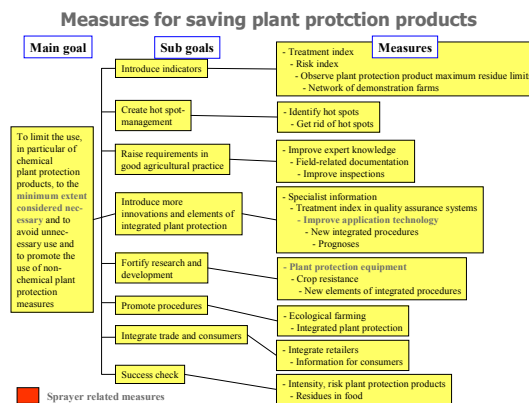
Figure 1: Measures for saving plant protection products

There is an evident need for action in equipment technology with regard to research and the development of new innovative techniques for applying plant protection products more exactly and effectively or for individual measures which do not use chemical plant protection products at all [2, 3]. Moreover, further initiatives and resources are needed for introducing new plant protection techniques/procedures into agricultural practice, even if the efficiency and economy of these new developments does not correspond entirely with standard techniques and procedures at first.

The following are examples of particularly innovative technical developments for saving on the use of plant protection products:

- Recycling equipment for viticulture and fruit growing, which has become particularly well known for its high drift reduction, guides a large part of the spray liquid which has not been deposited on the crop back into the tank. The saving effect depends to a large extent on the vegetation and can constitute up to 70 % at the beginning.
- Air-assisted sprayers in fruit growing and viticulture which recognise gaps in the foliage using sensors and switch the nozzles on and off correspondingly can save up to 30 % a year on average.

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- The two phases treatment of viticulture works with 2 dosing systems which are independent of one another. The insecticides and botryticides which are important for keeping the grapes healthy are only treated in the grape zone whilst the basic treatment to protect the rest of the foliage is applied over the entire height of the vineyard.

- Herbicides application in grape vine rows, where the nozzle only opens, by means of a green detector, when it detects weeds, can save up to 90 % of the plant protection product.

- The aim of precision farming is to take into consideration the heterogeneity of a crop/weeds within an area when applying plant protection products, moving away from the idea of using the same application rate per hectare. The savings resulting from this are stated by experts at being up to 60 %.

- As far as wiping equipment such as the Rotowiper or Rotofix is concerned, the herbicide solution is applied to a roller which turns in the opposite direction to the direction of travel. The roller rolls over the surface and the exserted plants are wiped with the herbicide. The roller is wet with the amount of herbicide required to prevent it from dripping onto the soil. This technique is used above all for controlling sorrel in grassland and premature beet in sugar beet and for controlling vegetation on paved surfaces.

- Band sprayers are only mentioned here for the sake of completeness; they are by no means a new technical development. They reduce the amount of plant protection product used by up to 40 % compared to overall application.

There are also techniques and methods which do not require any plant protection products at all, as can be seen by the following examples:

Adapted application techniques make biological plant protection methods more efficient and economical. This was demonstrated years ago when *Bacillus thuringiensis* preparations were used to control the corn borer as well as the larvae of the potato beetle and the apple ermine moth. In order to be effective, insect-pathogenic bacteria and viruses must be taken in by the butterfly caterpillars to be controlled when eating.

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For controlling the corn borer, parasitic wasps (Trichogramma sp.) are used on approximately 10,000 ha/year in Germany. These tiny wasps parasitize butterfly eggs and are bred on the eggs of grain-damaging moth. One thousand or more parasitized eggs are glued onto little carton frames. Shortly before the Trichogramma hatch, these little frames are hung on the leaves of maize plants in the field [4]. Even though only approximately 20 minutes/ha are required for application, this method is not suitable for the treatment of large areas. Therefore, the parasitized eggs were put into hollow spheres to be spread manually whilst walking or from the tractor, **fig. 2.** In a third step, work on mechanised spreading with the aid of pressurised air and high-clearance tractors is ongoing. Initial implements featuring this technology are ready for use. Spreading from airplanes is being tested.

Figure 2: Hollow spheres whose content is spread shortly before the hatching of parasitic wasps *(Trichogramma)* for corn borer control

In Germany, mosquito larvae are primarily controlled using *Bacillus thuringiensis ssp. Israelensis*. Since the larvae live on the surface of calm stretches of water and eddy in their food, it is appropriate to station the bacteria in this area over
a longer period of time in order to optimise their intake. For this purpose, a specialised company developed an ice granulate in cooperation with KABS (Municipal Association for the Control of the Mosquito Pest) which is applied by

helicopter using a specially equipped and insulated granulate spreader, **fig. 3** [5]. The ice granulates falls onto the water surface, melt slowly, and thus release the

Bacillus thuringiensis toxin. Common carrier and formulation substances, which could also have side effects, are not necessary.
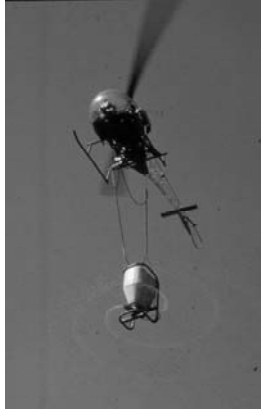

Figure 3: Bacteria *(Bacillus thuringiensis ssp. israelensis)* spread by helicopter contained in ice granulate for controlling mosquito larvae

In Germany, commercially manufactured recycling, sensor-controlled air-assisted sprayers and two-phase air-assisted sprayers, which have been tested in practice, have existed for several years. In the past, reference has been made to their drift reduction without reference to their great potential for reducing the rate of plant protection products applied. Figures 4 to 7 show that this potential for reduction can be considerable and can lead not only to a considerable relief for the environment through plant protection products which are not released, but also to considerable reductions in plant protection product expenditure for practitioners.

As can be seen in **fig. 4**, a reduction in the amount of plant protection products applied is influenced considerably by the configuration of the orchard, since reductions will be higher where there is less foliage and therefore obviously a smaller target area.
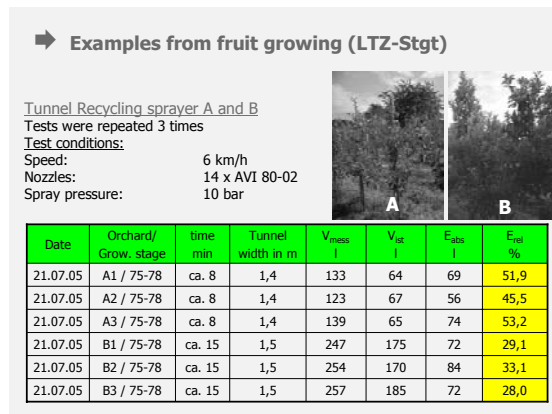
Examples from fruit growing (LTZ-Stgt)

Tunnel Recycling sprayer A and B
Tests were repeated 3 times
Test conditions:
Speed: 6 km/h
Nozzles: 14 x AVI 80-02
Spray pressure: 10 bar

Date	Orchard/ Grow. stage	time min	Tunnel width in m	V_{mess} l	V_{ist} l	E_{abs} l	E_{rel} %
21.07.05	A1 / 75-78	ca. 8	1,4	133	64	69	51,9
21.07.05	A2 / 75-78	ca. 8	1,4	123	67	56	45,5
21.07.05	A3 / 75-78	ca. 8	1,4	139	65	74	53,2
21.07.05	B1 / 75-78	ca. 15	1,5	247	175	72	29,1
21.07.05	B2 / 75-78	ca. 15	1,5	254	170	84	33,1
21.07.05	B3 / 75-78	ca. 15	1,5	257	185	72	28,0

Figure 4: Examples of tunnel recycling sprayers in fruit growing (LTZ-Stuttgart)

Air-assisted sprayers with sensor-controlled nozzles achieve negligible reduction only in orchards with few gaps, regardless of whether they operate with low or high application rates; see **fig. 5.**

Examples from fruit growing (LTZ-Stgt)

Sprayer with sensor controled nozzles
Test conditions:
Speed: 6 km/h
Nozzles: 16 x Albuz ATR rot
Spray pressure: 10 bar

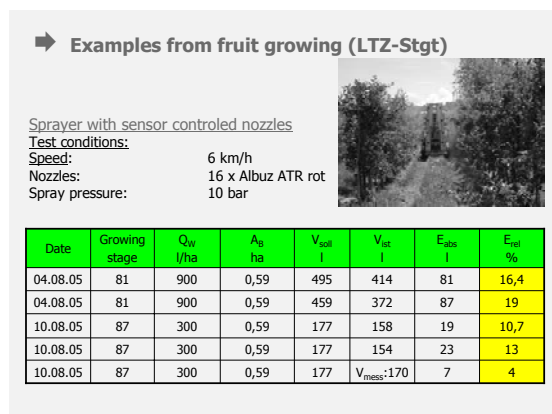| Date	Growing stage	Q_W l/ha	A_B ha	V_{soil} l	V_{ist} l	E_{abs} l	E_{rel} %
04.08.05	81	900	0,59	495	414	81	16,4
04.08.05	81	900	0,59	459	372	87	19
10.08.05	87	300	0,59	177	158	19	10,7
10.08.05	87	300	0,59	177	154	23	13
10.08.05	87	300	0,59	177	V_{mess}:170	7	4

Figure 5: Examples of sprayers with sensor-controlled nozzles in fruit growing (LTZ-Stuttgart)

The results from recycling and sensor-controlled air-assisted sprayers in viticulture are also impressive; see **fig. 6.** The sensor technique shows reductions in early growth stages of approx. 30 %. The results from recycling equipment decrease with increasing vegetation, from 50 % at the beginning to 22 %.
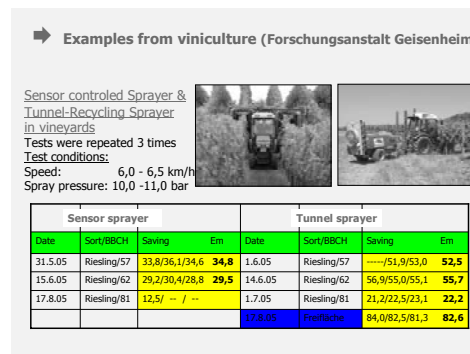
Figure 6: Examples of sensor-controlled sprayers & tunnel recycling sprayers in viticulture (Forschungsanstalt Geisenheim)

With the two-phase air-assisted sprayer which has 2 separate spray tanks and applies the expensive botryticides only in the grape zone, reductions between 40 and 60 % can be achieved, depending on the training system; see **fig. 7.**
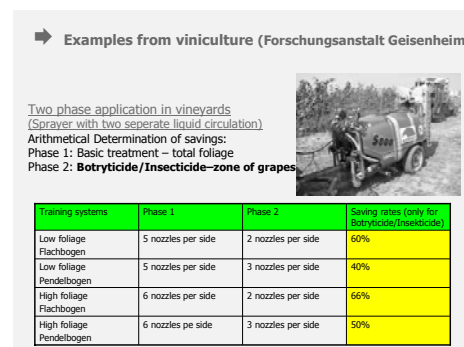

Figure 7: Examples of two-phase application in viticulture (Forschungsanstalt Geisenheim)

These results show that new and modern plant protection equipment is clearly able to reduce the amounts of plant protection products applied considerably, but that the amount of reduction in individual cases depends greatly on external conditions.

This has led the Institute for Application Techniques at the JKI to develop a testing procedure with which to define reproducible and reliable reduction values.

Materials and Methods

The reduction potential of plant protection equipment is defined as the amount of plant protection product which can be saved by technical measures to plant protection equipment without changing the noninal application rate in l/ha or kg/ha. Reductions can be made, for example, by collecting and returning spray liquid which has not been deposited, or by switching individual nozzles off using sensors or spray maps.

Trial area: The crop should be spaced uniformly and should not have any gaps (if appropriate these should be recorded).

Fruit farming: The trials should be carried out in commercial orchards with regular varieties and
cultivation methods with single repetition for the growth stages
BBCH 00 (bud development) to BBCH >72 (development of fruit). Young cultivations should also be incorporated into the assessment. The trials should record rootstocks, crown height and plant spacing in and between rows. The minimum row length should be 100 m. The orchard and the trial procedure should be documented by several digital pictures.

Viticulture: The trials should be carried out in vineyards with regular varieties and cultivation methods with single repetition for the growth stages BBCH 12 (preflowering stage) to BBCH > 75 (full foliation stage). Row spacing, vine spacing, leaf wall height, training shape, slope gradient and age of the crop should be recorded. The minimum row length should be 60 m. The vineyard and the trial procedure should be documented by several digital pictures.

Arable farming: The trials are to be repeated once on a test area which is representative of the   intended use.
 The area to be treated should be at least 1 ha in size.
 The test area should be recorded using pictures.

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Trial procedure

The entire trial area is treated with water.

The following weather data should be recorded during the trials:

- wind speed

- wind direction

- air temperature

- relative air humidity.

Weather data must be measured 5 m away from the trial area at the following heights:

- arable farming: 1 m

- viticulture: 3 m

- fruit farming: 4 m.

The air temperature should not exceed 25 °C for the duration of the trial nor the wind speed 5 m/s. Trial parameters must be recorded in their entirety.

The trial design should be recorded with pictures, taking into consideration the following information:

- a picture extract must be taken between 2 trees or 2 vines – centred in height and width.

- the background should be defined by a non-transparent film or canvassed frame.

Measuring method

The nominal application rate for the trial is determined by a calibration test with the equipment (nozzle control, for example, must be de-activated). The actual application generally a rate is calculated, while and amount is measured, metered for the equipment is determined by metering the refilled volume into the tank. To this end the spray level is marked on the tank before the trial begins. After the trial, the amount sprayed (actual application rate) is determined by metering the refilled volume using an appropriate measuring device (measurement error +/- 1.5 %). The determined spray pressure which is related to the driving speed should be maintained during the trial with a tolerance of +/- 5 %.

The treated area is calculated as follows:

A=R*S

with $\quad$ A = treated area in m^2

$\qquad$ R = row width or working width in m

$\qquad$ S = route driven in m with sprayer switched on

$\qquad$ (the sprayer turning does not count as part of the route).

If possible, imperfections within the crop such as badly damaged or missing trees or vines should not be included in the treated area.

Evaluation and illustration of results

For each trial, the reduction rate E must be determined in %

E= (nominal application rate – actual application rate) * 100/nominal application rate

The calculation of the reduction rate must be corrected, if possible, by the percentage resulting from the influence of imperfections in the crop (badly damaged or missing trees or vines).

Decision

(1) $\quad$ The plant protection equipment is registered by the JKI, Institute for Application Techniques, in the register of loss reducing equipment once testing has shown that the equipment has achieved at least a reduction of > 15 %.

(2) $\quad$ Before registration, the JKI hears the expert committee on plant protection equipment, which supports the JKI in its decisions in accordance with the test regulations.

It was decided against classifying equipment into reduction classes, similar to drift reduction classes, because a representative reference cropping area is required for all growing areas. Since the conditions in fruit growing and viticulture vary greatly from growing area to growing area, it has not been possible to agree on one fruit growing area or one vineyard as being representative for all growing areas.

Notification

The JKI publishes registrations and deletions in the register of loss reducing equipment in the Federal Gazette and the JKI-Bekanntmachungen (notifications).

Entry into force

The JKI describes the testing of plant protection equipment with regard to reduction potential in detail in JKI Directive 2-1.2 [6] and has been offering these tests since 1.01.2007

Manufacturers or distributors who are interested in testing for reduction must submit an application for testing to the Institute for Application Techniques.

On receipt of this application for reduction testing, the Institute first of all checks to see whether the equipment to be tested fulfils the general/legal requirements, since only once these basic requirements have been fulfilled is further testing for reduction possible.

The applicant must submit trial results for evaluation with regard to reduction testing to the Institute for Application Techniques in accordance with JKI Directive 2-1.2; the Institute then decides on inclusion in the register.

The first inclusions for equipment which reduces the use of plant protection products in the register of loss reducing equipment in the section reduction were made in the year 2008; they are stated below.

Research Results

The following four items of plant protection equipment have been tested successfully for their reduction in the use of plant protection products:

Figure 8: ECO-Reflex; sensor-controlled orchard sprayer

Figure 9: Lipco-tunnel sprayer TSG-N2 (two-row)

Figure 10: Lipco-tunnel sprayer OSG-N1 (one-row)

Figure 11 Wanner WKR-recycling sprayer (collector)

The tested equipment is characterised by the following technical specifications:
ECO-Reflex sensor control for air-assisted sprayers in viticulture and fruit growing (G 1773) consisting of a sensor support on the drawbar of the respective equipment with infra-red sensors, extra accessories for locking the drawbar into place and individual nozzle control for the nozzles situated at the blower outlet via solenoid valves. The equipment was tested with the trailed sprayer Wanner SZA 24/1000-100M (viticulture) and with an NA 32/1000 (fruit growing). The air-assisted sprayer is operated using the ECO-terminal by

Müller-Elektronik with electromotive pressure regulation and an electric pressure sensor.

Lipco-tunnel sprayer TSG-N2 for viticulture (G 1407) with recycling device consisting of two spray tunnels with four spray walls (which are also collecting walls) made of plastic, each with an integrally moulded sump which is slid in and out via two hydraulic cylinders.

The sprayer can be adjusted infinitely to different row widths via the hydraulic cylinders. The collected liquid is recirculated using injector nozzles.

Lipco-tunnel sprayer OSG-N1 for fruit growing (G 1410) with a spray tunnel consisting of two spray walls whose distance to each other can be varied, made of polyethylene with integrated blowers (version 7076 with 3 m tunnel height, version 7077 with 3.5 m tunnel height). The top of the spray tunnel is covered with a polyethylene film. Spray protection devices made of fibre-reinforced rubber are

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attached to both sides of the spray tunnel at the front and the back. A cross flow fan is mounted to each spray wall with a roller diameter of 150 mm, driven by hydromotors. A collecting tray with a sieve is situated below each spray wall. The collected liquid is sucked back by one injector per wall. Wanner WKR-recycling sprayer for viticulture and fruit growing (G 1379) consisting of collecting walls which can be swivelled out to the side to collect and return spray liquid which has not been deposited on the crop. The distance between the collectors and the middle of the blower can be adjusted infinitely between 910 and 1380 mm. Each collector consists of two lamella sets with the dimensions 1120 x 1200 mm and 1120 x 600 mm. The lamella depth is 130 mm. The collectors meet at the bottom in a sump from which the recycled liquid is returned to the spray tank.

The results of the tests carried out with the ECO-reflex sprayer in accordance with JKI-Directive 2.1.2 can be summarised as follows, **fig. 12**:
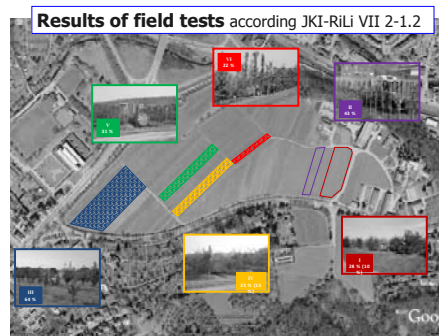
Figure 12: Examples of savings for the first entries of ppp-saving equipment in the register of loss reducing equipment

The tests show that reductions of 22 to 64 % can be achieved with the sensor-controlled sprayer. They also show that these reductions are influenced considerably by the orchard and the training system. It is therefore thought practical to present the reduction values together with pictures of the respective orchard or vineyard, and not to state the average value or the variation range for the individual results. It can be assumed that practitioners are able to estimate the expected reduction potential of the tested sprayer on the basis of individual results

and pictures of the orchards or vineyards to go with these for their own orchards and vineyards.

The reduction results for the other equipment are available on the Internet at the following address: www.jki.bund.de – Pflanzenschutzgeräte – Gerätelisten – Verlustmindernde Pflanzenschutzgräte- Section: Informationen zu Pflanzenschtzmittel einsparenden Geräten

The website is constructed as mentioned, making it fairly simple to use equipment for reducing the use of plant protection products in practice.

Discussion and Conclusions

At present, new innovative techniques are being evaluated, notably with regard to their potential for reducing drift. Further advantages such as reducing the amount of plant protection products used are often not considered. However, new technical developments have shown that plant protection equipment can sometimes reduce the amount of plant protection products used considerably . Moreover, several Member States have either already established reduction programs or are in the process of developing them, which also emphasise or specify the role of the equipment technology.

This has prompted the Institute for Application Techniques at the JKI to develop a test method for calculating reliable and retraceable values for the technical reduction of plant protection products.

The Institute for Application Techniques at the JKI now offers testing for reduction as a further element of official equipment testing with the consequence that the equipment which passes the test is included in the register for loss reducing equipment in the section reduction and is published in the Federal Gazette and on the Internet.

Four items of equipment have already been tested, registered and placed on the Internet.

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It can indeed be assumed that future sponsorship projects will favour above all equipment which has been proved as being environment-friendly because it releases less plant protection product whilst remaining as effective. This testing is expected to meet increasing interest from equipment manufacturers, farmers, authorities and consumers. It could also lead to the testing method being developed further and extended to developments in equipment where the evaluation of biological efficacy is also necessary.

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PRACTICAL USE OF METHODS AND TECHNIQUES IN MONITORING OF CUTWORM IN SUSTAINABLE AGRICULTURE

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Keywords : cutworms, *Agrotis segetum*, *A. exclamationis*, light trap, soil sample, pheromone trap, short-term forecasting, sustainable agriculture

Abstract

The studies on cutworms infesting sugar beets and wheat crops were carried out in the years 2005 - 2008 in three locations: Poznan (Institute of Plant Protection), Winna Góra (Agricultural Experimental Farm of Institute of Plant Protection) and Więcławice (formerly Sugar Beet Breeding Research Station). The observations performed during the moth flights from May to October included two cutworm species, namely: turnip moth (*Agrotis segetum* Schiff.) and heart and dart cutworm (*A. exclamatonis*). In studies three common methods for harmfulness assessment and the two cutworms species flights activity were compared, (a) light traps; (b) pheromone traps and (c) sifting standard soil sample for larvae presence. The third methods (c) turned out to be unsuitable in practice, because of time-consuming and low probability finding cutworms larvae in soil, while low number of cutworms cause severe injuries in crops. The pheromone traps proved that their usage is the only economically and viable method of Noctuidae spp monitoring population. Improved method of short-term forecasting for the young caterpillars turnip moth occurrence in sugar beets and cereal plantations support farmers to perform chemical treatment in biologically and economically correct time.

Introduction

In case of root crops protection in Poland signaling of the threats imposed by pests to crops has been used on a small scale so far and concerns only several species of phytophags [*Walczak1999*]. For the last several years different sorts of traps that signal appearance of a specified pest species on the plantation have been introduced and adapted for local conditions. The range of traps used for monitoring of the pest appearance and flight onto cultivated plantations is very diversified. It includes traps containing chemicals and synthetic pheromones, as well as mechanical traps (soil traps, sticky boards) and light traps [*Leinonen et al. 1998, Lipa 1977, Paruch 2001, Wiech et al. 2001, Walczak 2004*]. The possibilities of signaling with the usage of satellite signaling and molecular biology technologies should be also taken into account [*Boczek i Dąbrowski 2005*]. The agrophags that cause the largest losses in root crops are at present the soil pests, and especially the cutworms. Cutworm occurs in Poland every year, however, every few years its intensity is so high that they cause severe economic losses. This pest damages the root of the beet, eats up the leaves and destroys the beet sowing completely. The beet crop losses caused by the cutworm caterpillars may amount at between 10% and 30% [*Walczak and Jakubowska 2001*]. The cutworm caterpillars lead hidden lifestyle; i.e. they remain hidden by day and feed intensively by night. Therefore, fighting these phytophags is difficult and the available chemical methods will not always bring the desired results. The main reason for the chemical treatments being so ineffective is that the protective procedures are not performed in their due time. Catching moths in light traps is the most often used method for signaling the appearance of cutworm. Luring the moths with the UV light enables catching both males and females, but along with them other species of insects get caught as well. At present, with regard to catching males of particular species, using pheromones traps is a much more selective method [*Esbjerg 2003, Rogowska and Wrzodak 2006*]. The aim of the research was to evaluate the usefulness of the light and pheromone traps for monitoring, determining and optimization of the chemical pest management.

Materials and Methods

The observation was carried out in vegetative season between 2005 and 2008, in the arable fields of the farm owned by the Field Experimental Station of the Institute of Plant Protection in Winna Góra and in the former Sugar Beet Breeding Station in Więcławice. Moreover, soil traps have been made on sugar beet plantations in the Field Experimental Station of the Department of Soil and Plant Cultivation in Swadzim at the Poznań University of Life Sciences. The research compared three techniques recommended for estimating the threats that the cutworm caterpillars pose to crops and for monitoring flights of two species of cutworm moths: Turnip moth (*Agrotis segetum* Schiff.) and Heart and dart moth (*A. exclamationis* L.) on the plantations:

(a)   Light traps. The light traps used for catching moths were composed of a glow tube (250 WMI Mix) supplied from an AC source. Moths were caught from spring to autumn in 2005 and 2006. Moths (males and females) caught in the light traps were controlled three times a week. Moths picked from the traps were systematically segregated and marked.

(b)   Pheromone traps for catching males. In case of pheromone traps Hungarian dispensers and triangle traps with replaceable sticky floors were used. The traps were placed on cultivation fields with sugar beet, winter wheat and winter barley. Readings were made and floors replaced once a week from 2005 to 2007 in the periods from June to July and in 2008 from May to July. The collected results were processed statistically using the Kruskal-Wallis test.

(c)   Soil traps – soil taken from standard pits (pit size: 25x25x30 cm) was sieved in order to find if any caterpillars were present. This method was applied in autumn (September, October). The occurrence of pests was controlled 2 or 3 times during the plant vegetation period and once after the beet harvest. After sieving the soil from traps, insects found were marked and counted. In total 50 soil samples were checked.

Research Results

In the four years of the research duration, *A.segetum* and *A. exclamationis* moths were being caught throughout the entire period of conducting observations,

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which conforms the efficiency of the pheromones and light traps applied. The last techniques turned out to be little useful in practice due to a significant amount of work and small probability of finding any larvae, even in a density that causes significant damages on sugar beet plantations (tab. 1). This indicates also a necessity to verify the recommended threshold of cutworms in root crops.

Table1. Species composition and quantitative structure of *Noctuidae* caterpillars captured in examined locality and years.

Pests	Average number of larvae (caterpillars) per 1soil outcrop								
	Winna Góra			Swadzim			Więcławice		
Lepidoptera-Noctuidae:	2005	2006	2007	2005	2006	2007	2005	2006	2007
Agrotis segetum Schiff.	1,0	1,0	0,3	0	0	1,0	0,1	1,0	0
Agrotis exclamationis L.	0	1,2	0	0	0	0,5	0	0	0
Xestia c-nigrum L.	0	0	0	0	0,7	0,5	0	0	0,1
Other species	2,4	2,0	1,2	1,0	0,9	0	2,4	1,4	0,7

In 2006, on the premises of the Field Experimental Station – Winna Góra, the first Turnip moths and Heart and dart moths were caught in the end of May. The maximum flights of *A.segetum* were observed on 28 June, 2 August and 16 August which persisted up to 13 September; and of *A.exclamationis* from 28 June to 2 August. In Więcławice, the first Turnip moths and Heart and dart moths were caught like in 2005 around 20 May. The intensive flight of the first generation of the two examined species of cutworms, i.e. Turnip moths and Heart and dart moths, was observed from 15 July to 5 August. The maximum flight of the second generation of all examined species fell from the third decade of July to the third decade of August.

In 2005 vegetation season, in Winna Góra, the first Heart and dart moths were caught from 8 June. The first individuals of the Turnip moth were observed from mid-June. The maximum flights of *A.exclamationis* were monitored on 26 June and persisted up to 6 July; and of *A.segetum* they were observed from 3 August to 20 August. In Więcławice, the first Heart and dart moths were caught in the third decade of May (around 19 May). The intense flight of the first generation of the

two examined species was observed from 3 June to 3 July. The maximum flight of the second generation of the pests fell in mid-August and lasted until the second decade of September.

On the grounds of the results obtained it was found that in the research period the Turnip moth occurred with alternating intensity, and was more populous on experimental fields in Więcławice i Winna Góra. The highest amount of this species was caught in 2006 (277 individuals) and the lowest in 2005 (158 individuals). In each of the examined years, activeness of moths was observed in the third decade of May. In the vegetation seasons of 2005-2006, two periods of more populous catches of males were determined: the first one in June/July (1st generation), the other one in August/September (2nd generation). In 2005-2006, the beginning of the regular flight of the Heart and dart moth was recorded on the average around 25 May. The flight period of imagines of this species was relatively short and lasted until the end of July. The highest number of moths was caught using the light trap in Więcławice and Winna Góra in 2006 – 176 individuals. Te light trap method has the following disadvantages: need for electricity and a greater work consumption.

Table2. Number of trapped male of Turnip moth individuals of the experimental farm during the 2005-2008 growing season, Więcławice and Winna Góra.

Year/Locality	Number of sample	Period of monitoring	Number of trapped male moths	Average number of moth per 1 trap
2005 Więcławice	2	May-July	17	8,50
Winna Góra	3	May-August	65	21,67
2006 Więcławice	1	May-July	32	32,00
Winna Góra	4	May-August	52	13,00
2007 Więcławice	1	May-July	34	34,00
Winna Góra	4	May-August	98	24,50
2008 Więcławice	-	-	-	-
Winna Góra	4	May-August	81	20,25

Results of the attracting properties of pheromones were presented in table 2. The tables show that in the two places where the research was performed the beginning of the flight of the Turnip moth and Heart and dart moth was observed in the first decade of June and in the first half of May 2008. Results obtained using the two

catching methods were convergent in case of catches in Winna Góra, and different in case of Więcławice. In Więcławice it was observed that according to the catches from the light traps the moth flight took place 2 weeks earlier than for catches from the pheromone traps. In the examination over the pheromone traps in the research years no relevant discrepancies were found between the two places or between the individual years.

Discussion and Conclusions

Research conducted by *Olszak [1999], Szwejda and Wrzodak [2006]* confirm that in the recent few years traps with insect pheromones working as the attracting substance have been applied most widely, and probably will also in the future, to support the procedure of determining the most optimal term for pest control. For both compared methods, very close results were obtained in respect of the cutworm moths' flight on the same field in the vegetation season. Pursuant to the authors' own research results, and analogically to the experiments of *Buszko and Nowacki [1990]*, it was found that high temperature has a positive effect on the size of catches. It was observed that the cutworm catch ability in the light traps changes proportionally to the course of temperature alternations. This dependence was particularly visible in Więcławice in 2006 from 22 July to 10 August, when with the higher temperatures and lower humidity the catches were more populous. For both places it was found that the moth catches were most populous at night (11 pm to 2 am) temperatures of 16-18°C. A large decrease of the night temperature, even when the night is warm in the beginning, causes a significant decrease in the moth activeness. Such a situation occurred in August 2006, when low night temperatures and heavy rainfalls were a cause of small moth activeness.

Due to the significant economical losses caused by cutworms on plantations of root crops, and in particular of beet, it is recommended to introduce a widespread monitoring of flights of the discussed pest on plantations in the cultivation regions. As the conducted research proves, the economic losses are caused mainly by incorrect term of protective treatments. As the vegetation period of sugar beet is long, insecticidal treatments have been performed several times and often at an

undetermined time. And they need to be carried out in a strictly specified time, based on the monitoring of the pest flight onto plantations.

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INVESTIGATION OF REDUCTION OF THE ENVIRONMENT DAMAGING EFFECTS DURING SPRAYING

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Keywords: environmental protection, drift, sprayer, wind tunnel

Abstract

The success of chemical plant protection and its effect on the environment depend on the used machines and technologies. For example, the type of sprayer system and its adjustment have an effect on pesticide drift. Chemical losses need to be reduced without decreasing the spray quality.

In order to analyse some factors influencing drift, we performed several simulated drift measurements in a wind channel. We investigated the drift of drops coming from TeeJet nozzles (different types), using different settings on our system such as working pressure and laminar air speed. We described the level of drift by calculating the relative coverage on water sensitive paper sheets, which were situated on the floor of our wind channel with a distance of one meter between each.

Introduction

Agricultural cultures can be efficiently protected against yield-decreasing and debasement caused by pests, diseases, and furrow weed only if the expertly chosen insecticides will be sprayed on-time, in appropriate quantity and evenly on the entire target field. If the expected result lags behind, the farmers often suspect the applied insecticide of being inefficient, indeed it is obvious, too, that the insecticide could not be sprayed adequately onto the target field. One essential

condition and requirement for the sake of the successful and effective pest-control is the utilization of both the appropriate machine and technology.

The effect of the chemical control on the environment depends significantly on the used machines and the technology, respectively. The machine system and its build-up as well as the technology applied during the pest-control activities influence drastically the waste-level of the chemicals, moreover its treat and pollution onto the environment.

Materials and Methods

In the wind tunnel the modelled drift investigations were carried out with 4.0 and 6.0 m/s laminar wind speed and operational spray pressures were set to 3.0 and 4.0 bar. During the investigations from the different types of nozzles (TP, DG, AIXR, AI) the most used 110 04 types were used. In the wind tunnel ws papers were positioned: 1 piece directly under the spraying nozzle which had a 500mm fixing height and 7 others ws papers were positioned 1 m from each other; the size of the paper was 52x76mm. After the test the papers were collected and scanned. The relative grade of covering was analyzed by the National Instruments LabVIEW Vision program.

Research Results

From the results of the analysed ws papers were depicted the following diagrams.
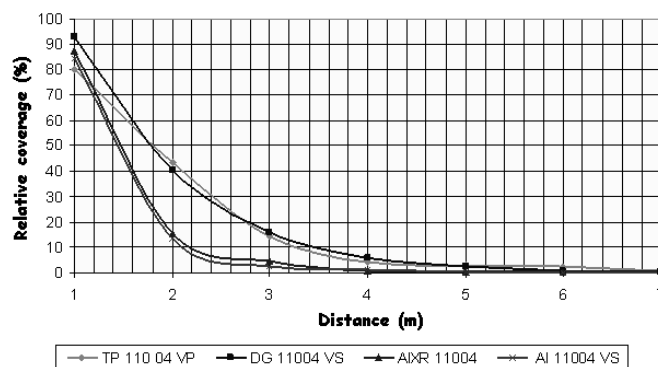
Figure 1: The drift of the TeeJet nozzles (p=3.0 bar, v=4.0 m/s)

In the fig. 1. the results of the test can be seen when the work pressure was 3.0 bar and the wind speed was 4.0 m/s. The drift of the classical type of nozzle is significant on the hole range (1-6 m: 80,1-2,6 %) and the relative grade of covering also significant ($\geq$1 %) on the measuring border (7 m). The results of the drift guard type DG 11004 VS nozzles also high till 6 m (93,0-1,0 %) but on the 8th paper just 0,4 %. The passive injector types AIXR 11004, and AI 11004 VS nozzles up to 4 m more than 1% (87,2-1,0 %, and 84,3-1,2 %), but from 5th m the drift is neglectable.
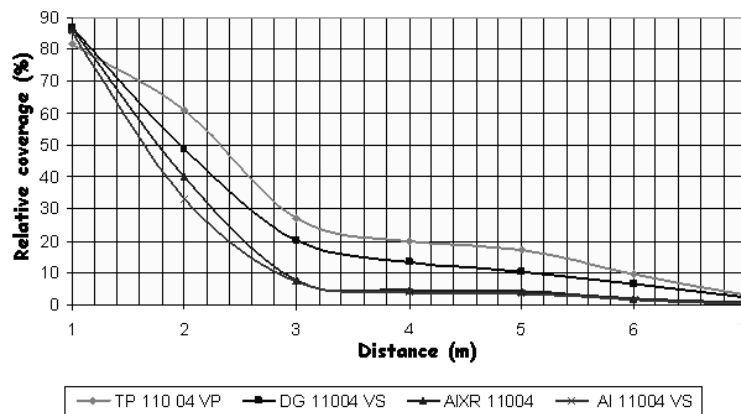
Figure 2: The drift of the TeeJet nozzles (p=3.0 bar, v=6.0 m/s)

In the fig. 2. the results of the test withwork pressure 3.0 bar and the wind speed was 6.0 m/s observable. The drift of the classical type of nozzle and the drift guard type DG 11004 VS nozzles also significant on the hole range (81,6-3,0 %, and 86,9-2,2 %). The passive injector types AIXR 11004, and AI 11004 VS nozzles up to 6 m more than 1% (86,6-2,1 %, ?illetve? 85,3-1,3 %), but from 7th m the drift is still neglectable.
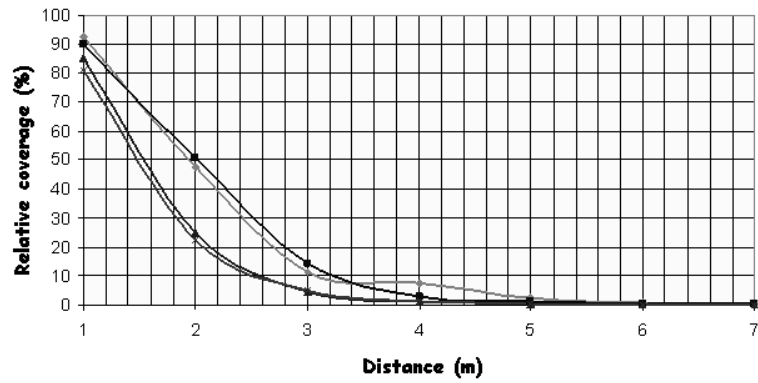
Figure 3: The drift of the TeeJet nozzles (p=4.0 bar, v=4.0 m/s)
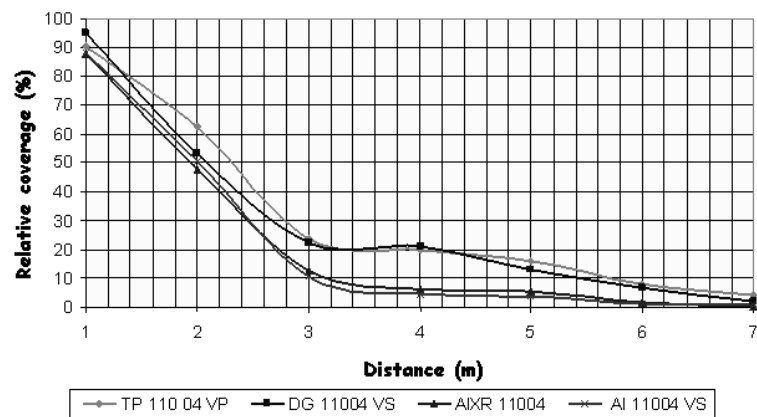
Figure 4: The drift of the TeeJet nozzles (p=4.0 bar, v=6.0 m/s)

In the fig. 3 and 4. the results of the test withwork pressure 4.0 bar and the wind speed were 4.0 and 6.0 m/s can be seen. The drift of the classical type of nozzle TP 110 04 VP and the drift guard type DG 11004 VS nozzles also significant up to the 5th m (92.2-2.7 %, and 90.0-1.3 %) from 6th m the drift were reduced (0.8-0.4 %, and 0.0-0.3 %) for 4.0 m/s wind speed but for 6.0 m/s wind speed the drift is very high (90,1-4,0 %, and 95,0-2,0 %). The passive injector types AIXR 11004, and AI 11004 VS nozzles up to 4 m more than 1% (85,4-1,1 %, and 81,1-1,2 %) for 4.0 m/s wind speed and for 6.0 m/s wind speed up to 6 m more than 1% (87,6-1,8 %, and 88,3-1,1 %), from 5th and 7th m the drift were neglectable.

Discussion and Conclusions

Based on the results of the simulations verifiable that in the case of the classical TP 110 04 VP types under different conditions the drift is significant in the whole range.

In the case of the drift guard types DG 11004 VS the results were not significantly different for 6.0 m/s wind speed. For 4.0 m/s wind speed on the border of the measurements was recognizable some slight drift reduction based on the relative grade of covering.

The passive injector types AIXR 11004, and AI 11004 VS on both operational pressure for both 4,0 m/s and 6 m/s wind speed the drift reductions were significant compare with the TP and DG types.

Based on the results of the wind tunnel investigations statable that the classical edge type nozzles are not recommendable for bigger than 3 m/s wind speed because the driftage and the maximal drifted distance also widely increase. Hereby the possibility of the environmental damage also increases.

The drift guard nozzles against the driftage are able to reduce the driftage also just till 4 m/s so these types are also not recommendable for over 4 m/s wind speed.

The passive injector nozzles are able to reduce the driftage up to 6 m/s wind speed (under proper operation conditions: working speed, operational pressure, distribution).

A MULTIDISCIPLINARY APPROACH TO DETERMINE PESTICIDES POLLUTION SOURCES IN DRINKABLE WATER CATCHMENT: STUDY CASE (BELGIUM).

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Keywords: pollution sources, water, pesticides

Abstract

In the Walloon Region (Belgium), a Committee of Investigation has been set up in 2007 to investigate and determine the potential pesticides pollution sources in drinkable water catchments.

Following the diagnosis method, base on the AQUAPLAINE method (Arvalis, France), the contamination source of two catchments has been quickly localized. These two catchments supply the water network, but only one was contaminated by the bentazone. In fields around the catchment, the pedologists and hydrogeologists found a restricted area near the catchments consisting in a very stony and filtering soil, where the ground water is shallow and the gravitating supply limited.

Indeed, another range of samples has been taken on three points of the water network. Only one sample exceeded the permitted maximal pesticides (bentazone) concentration although all water samples came from the same water tower. The investigation allowed locating a farm with a well upstream from the contaminated

sample. Due to a defective no-return valve, the water from the well contaminated the water network of the village.

In conclusion, the multidisciplinary Committee of Investigation determined a double pollution source of the water supply; one coming from the catchments supplying the water network and the other directly involving the water network.

Introduction

In Wallonia (Belgium), groundwater water supplies 80 % of the population needs. It mainly comes from drilled wells, gallery or from spring. Due to the shallowness (few meters in some places) some of them could be contaminated by pesticides, upper than drinking water standard of 0,1 µg/l.

A committee of investigation has been created in 2007 by the Agricultural Research Centre of Wallonia (CRA-W) and financed by the public body in charge of water protection (SPGE) to cope with this problem. This Committee consists of a multidisciplinary team of experts as agronomists, cartographers, pedologists, phyto-chemists and hydrogeologists. The committe studies the cause of catchment pollution by pesticides and proposes specific measures to solve the problem.

This paper presents the results of the committee of investigations made for a water company that supplies a population of about 2000 inhabitants of a village located in the Condroz area (south-eastern part of the Walloon region).

Materials and Methods

The two production drilled wells (Tillesse and Malplaquaye) are located in the sandstone aquifer of the Famennian formations. The non-confined aquifer is placed in the weathering part and in the fractures of the sandstone. The water table is only few meters close to the surface. The well productions are 18314 m^3/year for the Tillesse well and 14696 m^3/year for the Malplaquaye well. The water of two wells is mixed in a water tower tank before its distribution.

Analysis, made in January 2008 (table 1), showed that only one production well and thus, one catchment was contaminated by the bentazon.

Table 1 : Results of analysis carried out in the catchments

Date	Pesticide concentration	Location
07/01/2008	202 ng/l of bentazon	Well of Tillesse
07/01/2008	All pesticides < 25ng/l	Well of Malplaquaye

The committee studied the cause of this pollution by using a methodology based on the AQUAPLAINE diagnosis developed by Arvalis (Institut du Végétal, France) and consisting of 4 steps (Arvalis 2003):
- Preparing the diagnosis using existing information;
- Plot diagnosis using data bank completed by field observations;
- Meeting and discussions with pesticide users;
- Final diagnosis and remediation proposal.

In February 2008, three samples were taken at three different places of the water supply network (location: figure 3). Only one sample showed pesticide concentrations over drinking water standard. The water conveyance being supplied with water from the same water tower, pollution occurred upstream from the sampling point on the network.

Table 2 : Results of analysis carried out in the network

Name	Concentration of bentazone (ng/l)	Date of sampling
X1	28.2	11/02/2008
X2	35.8	11/02/2008
X3	115	11/02/2008

Research Results

According to the investigations conducted by the research committee there are two sources of pollution: the first one comes from the well (Tillesse), the second one from the water supply network.

1/ Study of the catchment pollution

First step: Preparing the diagnosis using existing data

The first step consists of gathering available data to prepare a useful and efficient field visit. The following information were collected:

- Pesticide general information (use, application period, ?information or manufacturer label ?, analysis result,…).

- Landscape and fields environment (agricultural parcels, coverage, key elements of the landscape, cartographic data on the site, on the geology, hydrogeology and pedology context,…)

- Meteorological data (precipitation, evapotranspiration and field capacity).

In this case, the incriminated molecule is the bentazon. This herbicide was applied mainly on maize and peas. Intrinsic properties of the molecule indicate a potential risk for groundwater with a GUS (Groundwater Ubiquity Score) of 3,31. Nowadays, due to a lot of groundwater pollution in Europe, bentazon is only authorized to treat peas.

The catchment is located on a slope turned to the south-west. All fields around the catchment are used for agriculture (Figure 1). According to the geomorphologic and the hydrogeological context groundwater flow should occurs in a NE to SW direction.

In these fields, the pedologists found a restricted area near the catchment consisting in very stony and seeping soil. Those characteristics imply that this soil does not retain pesticides and other pollutants. More than this, the groundwater is very vulnerable because the saturated zone it is shallow. Indeed, during investigation on field, the groundwater level was found at one meter and twenty centimetres deep. Moreover, the infiltrating ?basins? that supply the aquifer is limited to the north-eastern topographical ridge located few hundred meters away from the well. All these information lead to conclude that the cause of pollution is closed to the catchment.
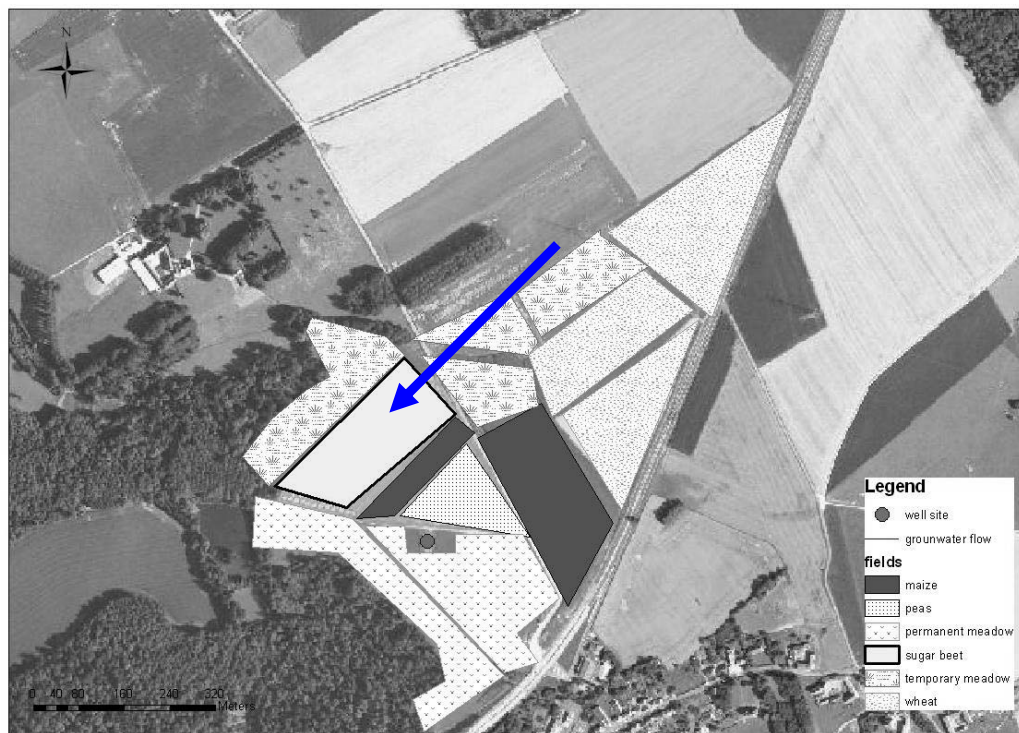
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Figure 1: Land use around the catchment in 2007

Second step: Plot diagnosis using data bank completed by field observations.

The land used around the catchment was defined (Figure 1). In the south, there were permanent meadows not treated with pesticides. In the North, there were two parcels of maize and one parcel of peas which could be treated with bentazon. Only one farmer possesses the fields of peas and maize around the catchment. The parcel of peas was rent to a food-processing society who decided of all the treatment.

Third Step: Meeting and discussion with the pesticide users

It is the most important step of this work because it allows to link the several plots to the pollution. The committee has to converse with the farmers to get information because there is not another way to get it. The information was collected to the farmer and to the food processing society about pesticides used on crops around the catchment. The society used bentazon on peas in June 2007. On the other plots of maize, the farmer did not use bentazon.

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Study of the water network pollution

The investigation allowed to locate a farm upstream from the contaminated sample (Figure2). In this farmyard, a well used to water cows was found. Due to the small capacity of the well, the farmer is also supplied with water from the public distribution.
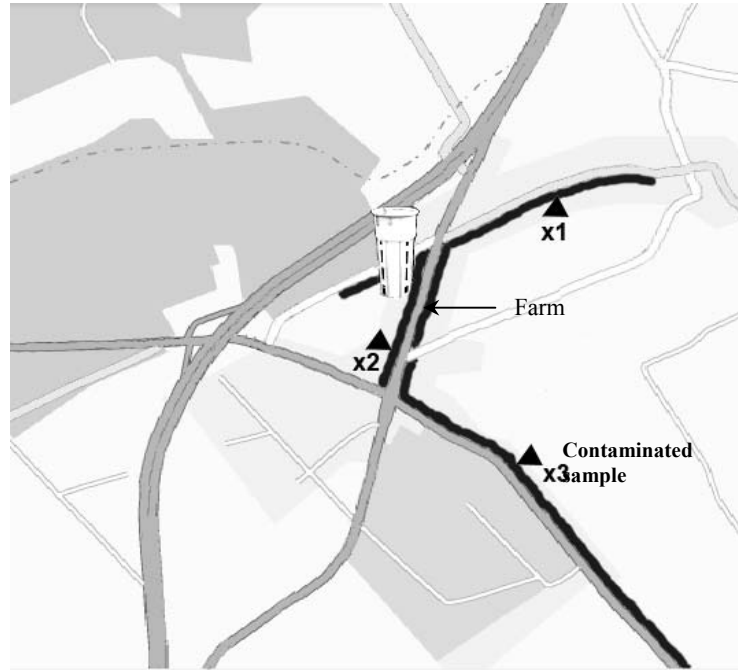
Figure 2: Map of the water network

The water supply to the cowshed is provided by the same pipe connected to the well and to the distribution network (figure 3).

Legally, the two pipes must be separated and the water meter must prevent the return of water from well to water supply network. Due to a defective no-return valve of water meter, the water of the well could spread trough the water network of the commune and contaminate it. The pesticide analysis of the water's well validate our hypothesis according to the well is the source of pollution as 92ng/l of bentazon has been found in the well
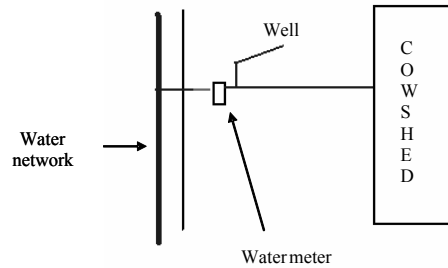
Figure 3: Connecting of the water network

Discussion

Fourth step: Final diagnosis and remediation proposal
The investigations have clearly identified two sources of pollution: one from the production well due to the proximity of the peas plot and the second one by the domestic well of the farm, not adequately equipped.

Peas plot
The bentazon is the only product used on peas with a wide spectrum against dicotyledon. In 2006, fields around the well catchment were seeded by pea. Normally, the farmer sows peas every seven years on the same fields, so the contamination should decreased in a near future. The only long time solution is to change the crop rotation and to avoid peas fields around the catchment. Nevertheless, the farmer does not want to change his crops rotation because peas crops are more profitable. Without compensation, he will go on cultivating pea. The others solutions is to prohibit or reduce the use of bentazon around the catchment.

Well of farm
Concerning the well of the farm, several solutions have been set up. The most important one consists in replacing the defective water meter to prevent the risk of water return from the well to the water supply network. The committee has to make this farmer aware of the risk of pesticide uses and advises him to avoid accidental contamination of his well (as filling or washing operations of his sprayer).
In Belgium, since 1997, domestic well must be registered, the farmer well was not. The Committee informs the farmer of the various administrative steps to register it.

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Conclusions

The first mission of the committee of investigation is to locate the pollution source and to propose solutions to stop the contamination. As the committee has not any authority, discussions with the different actors are always preferred. That is the reason why any sanctions against the farmer have been enforced.

At the end of the survey, the committee of investigation met the local authorities to explain them the various origins of the pollution. It stressed that the only way to protect the production well area was to define protection area around the well.

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THE EXPECTED CHANGES IN REGISTRATION OF FORMULATIONS OF PLANT PROTECTION PRODUCTS IN POLAND

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Keywords : registration, formulations, plant protection products

Abstract

The implementation of the Thematic Strategy on the Sustainable Use of Pesticides is likely to influence the formulations of plant protection products placed the Polish market. The fall of number of registered formulations in the form of powder is expected and the increase of the number formulations regarded as safer. The changes in registration of formulations for hobby gardens are probable. In spite of the expected ban for aerial spraying the decrease of formulations for aerial spraying is rather not to be expected

Introduction

Since accession to the European Community in 2004 the registration of plant protection products (ppp) in Poland depends not only on local needs and legal requirements but is regulated by common rules as well.

Renewed EU Sustainable Development Strategy was adopted by Heads of State and Governments at the European Council of 15-16 June 2006 *(A Sustainable, 2008)*. The overall aim of the Strategy is to identify and develop actions to enable the EU to achieve continuous improvement of quality of life both for current and for future generations, through the creation of sustainable

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communities able to manage and use resources efficiently and to tap the ecological and social innovation potential of the economy, ensuring prosperity, environmental protection and social cohesion. The tools to obtain the aim of the Sustainable Development Strategy are seven EU thematic strategies. One of them is the Thematic Strategy for Sustainable Use of Pesticides. Its implementation will result in significant changes of all legal regulations regarding plant protection in all member states and among them in Poland. The paper presents the expected influence of the legal changes in EU on registration of formulations of ppp in Poland.

Materials and Methods

The list of ppp placed on the Polish market in September 2008 was analyzed together with the proposed measures of The Thematic Strategy on the Sustainable Use of Pesticides *(Thematic Strategy 2006)*. The measures supposed to influence registration of formulations as well as their predicted influence were assessed.

Research Results

The implementation of the following measures of the Thematic Strategy is likely to influence the registration of ppp' formulations:

1. Research with the objective of improving health and well-being of European citizens through higher food quality and improved control of food production and related environmental factors, as facilitating risk assessment at farm level.

This measure can encourage research on new methods for biological control and development of the methods already used. It can contribute to development of new programs of integrated plant protection.

2. In the international arena, financial and technical assistance will be provided in numerous bilateral and multilateral programs which contribute to the safe handling and disposal of pesticides

The research founds can speed up the development of new, safer formulations of ppp.

3. Creation of a training system for professional pesticide users to ensure the awareness about risks linked to this use make users able to take all appropriate measures to find the least harmful means for solving a plant protection problem.

This includes guidance on the best choices among different products available for the same treatment.

The training system for professional users of ppp is well established in Poland. However if information how to make best choice among different products on the market will be emphasized enough in the program of trainings it should increase the demand on safer formulations for person performing the treatment, provided that there will be enough products registered to make a satisfactory choice.

4. Awareness raising of the general public through campaigns and information passed on through retailers.

It is important to remember that the "general public" or consumers, are also the ppp users and buyers (of course products marked as toxic can not be sold to this group of users). The ppp are used to protect ornamental plants in houses and bacons and to protect ornamental plants, fruit and vegetables in gardens. It should be stressed that the number of hobby gardens in Poland is significant. For this segment of market special (smaller) packages as well as formulations are produced. The typical formulation for non-professional users is for example AD - aerosol dispenser.

Implementation of this measure can reduce the demand for formulations destined for hobby users.

5. Prohibition of aerial spraying. Aerial spraying should only be used where there are no viable alternatives.

This can influence the reduction of demand for formulations used for aerial spraying like UL - ultra low volume liquid. It is doubtful however if this impact will be strong in Poland where nowadays aerial spraying is used mainly in forests protection with no alternative method available.

6. Development of Community - wide standards on Integrated Pest Management and establishment of necessary conditions for implementation of Integrated Pest Management.

As in Integrated Pest Management the emphasis is put to use all available non chemical methods of pest control this measure can increase demands for biological means of pest control thus influencing the registration of formulations.

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Discussion and Conclusions

In September 2008 there were 821 ppp placed on the Polish market (*List, 2008*). The most common formulations are intended to produce spraying liquid – their popularity follows the fact that spraying is the most frequent used method of ppp application in Poland.

Since the EU accession (01.05.2004) the number of ppp available for the Polish farmers continually decrease: during the first four years of EU membership there were 133 decisions regarding registration and 249 regarding withdrawal of ppp.

Wettable powders and soluble concentrates were significantly more often withdrawn than registered while suspension concentrates for seed treatment, water dispersible granules, aqueous capsule suspensions and preparations with the formulation code XX – others were significantly more often registered than withdrawn (*Matyjaszczyk, 2007*).

The implementation of the Thematic Strategy is likely to influence the withdrawals of the following formulations which are considered to be less safe: DP - dusting powder, DS – powder for dry seed treatment, SP - water soluble powder, WP - wettable powders, WS - water dispersible powder for slurry seed treatment. Powders, due to drifting, can negatively influence the health of person preparing the spraying liquid. It is probable that powder formulations will be slowly withdrawn and replaced by safer ones like MG - microgranules or CS – aqueous capsule suspension.

The demand for formulations often used in hobby gardens like AE – aerosol dispenser and AL – liquid to be applied undiluted should decrease due to implementation of the measures of the Thematic Strategy. On the other hand however, the number of these products is not very high: there are only 3 AE formulations and 29 AL formulations registered in Poland at present. Besides according the prognosis of agrochemical industry the global "home and garden" sector is expected to grow (*Beer, 2008*). The significant reduction of these formulations in Poland is therefore very doubtful.

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As the ban for aerial spraying to be introduced will be not total (aerial spraying will be permitted provided that there are no viable alternatives) it will probably not influence the formulations for aerial spraying. In Poland aerial spraying is used mainly in forest protection where there are no alternatives. The agricultural crops are extremely seldom treated from air mainly due to very high cost of this method of application. At present there are only 4 products registered in Poland with the formulation destined specially for aerial spraying UL – ultra light volume liquid. And it can be expected that this number will remain more or less the same.

Summarizing we can estimate that in Poland the fall of number of registered formulations in the form of powder is expected and the increase of the number formulations regarded as safer. The changes in registration of formulations for hobby gardens are probable but it is difficult to predict their direction. In spite of the expected ban for aerial spraying the decrease of formulations for aerial spraying is rather not to be expected

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DEVELOPMENT OF BIOFILTERS TO REDUCE THE QUANTITY OF PESTICIDES FROM RINSING AND CLEANING WATER OF SPRAYERS

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Keywords : pesticides, biofilters

Abstract

Several studies carried out in Europe showed the importance of direct losses to the contamination of surface water by pesticides. These pesticides losses can occur at the farm site when the sprayer equipment is filled with the pesticide formulation (spills, overflowing, leaking) and during the clean-up (rinsing) of the sprayer after the treatment. In Belgium studies were carried out on biofilters to treat in an efficient way effluents containing pesticides.

Biofilters consist in systems of 2 or 3 plastic containers of 1 m³ placed in a vertical pile and containing a substrate elaborated from a homogenised mixture of local soil, chopped straw and peat or composted material, able to absorb and degrade the pesticides. The different containers are connected between them using plastic valves and pipes. Biofilters are installed near the area for cleaning and rinsing the sprayer and the waste waters containing pesticides can be (or not) collected in an intermediate tank and sent using a pump into the top unit of the biofilter. Waste waters are staying about one day in each unit of the biofilter in order to allow the retention and the degradation of pesticides. The treatment capacity for 1 biofilter column is maximum 350 L of waste water a day.

Since 2002, a pilot study was carried out in Belgium in order to evaluate the efficiency of these systems. Twenty pilot systems were placed from 2002 to 2004 in several farms, agricultural technical centres or schools (producing cereals, sugar beets, potatoes, vegetables, fruits or ornamental plants) and in a municipal maintenance service. The efficiency of the biofilters was studied for several chemical classes of herbicides (triazines, urea, aryloxyalcanoic acids, chloroacetanilides), insecticides (pyrethroids, carbamates) and fungicides (dicarboximides, phenylamides, triazoles and strobilurines). The efficiency (yield) of the biofilters was determined by measuring the balance of the inputs and the outputs of the pesticides into the systems. The degradation of pesticides into the substrate was evaluated by analysing the pesticides into the substrate. The pesticides were monitored into the elutes and the substrates using validated methods by Gas Chromatography with Mass Spectrometry Detection (GC-MS) and High Performance Liquid Chromatography with UV Diode Array Detection (HPLC-DAD). The microbiological activity of the substrate was also evaluated by measuring respiration and some indirect parameters like dry matter content, Kjeldahl nitrogen content, organic content and biological oxygen demand (BOD).

The results of the experiments show an overall good efficiency (retention) of pesticides by the biofilter and a high degradation rate for the majority of pesticides. Moreover the output water contains very low pesticides concentrations and do not present any phytotoxicity. Biofilters allow to collect and clean a high amount of pesticides from rinsing and cleaning waters of sprayers. This contributes significantly to the reduction of water pollution by pesticides.

PhytEauWal is an on-going development project with the objective to share out the Best Management Practices, to promote the use of biofilters and to give its support to the agricultural and non-agricultural pesticides users, like with the public authorities, in order to reduce the impact of these products on the natural resources and the environment, and more particularly within the framework of the protection of drinking water resources.

Introduction

Biofilters consist in systems of 2 or 3 units (depending on the spray equipment of the user and on the configuration of the farmyard) and are located near the area for filling and rinsing the sprayer (figure 1). Each unit is made from a 1 m³ plastic container and the different units are stacked in a vertical pile and connected toegether using plastic valves and pipes. The biofilter substrate is elaborated from a homogenised mixture of local soil, chopped straw and peat or composted material, able to absorb or degrade the active substances. The waste waters containing pesticides are collected and sent using a pump into the top unit of the biofilter. Waste waters stays about one day in each unit of the biofilter in order to permit the retention and the degradation of pesticides. After the end of the spraying season, biofilters are refreshed (recycled) by mixing the one year aged substrate with new straw. The containers are refilled with this new mixture and allowed to settle during about 2 months before the new spraying season and therefore the new application of pesticides wastes.
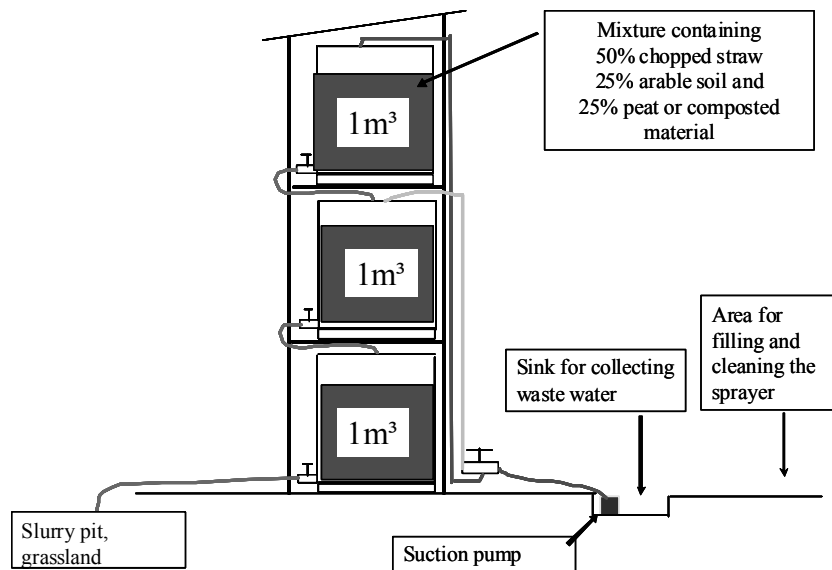
Figure 1. Schematic representation of the biofilter.

Materials and Methods

Twenty pilot systems (18 biofilters and 2 phytobacs) were installed between 2002 and 2004 in several farms, agricultural technical centres or schools selected in the loamy region of Belgium and producing cereals, sugar beets, potatoes, vegetables, fruits or ornamental plants and in a municipal maintenance service. During the 2002 and 2003 spraying seasons, the efficacy (yield) of the systems was determined by measuring the balance of the inputs and outputs for 5 tracer pesticides (atrazine, carbofuran, diuron, lenacil and simazine) brought on the biofilters. Results were expressed in percent of pesticide retained on the biofilters. During the 2004 and 2005 spraying season, the efficacy of the systems was determined for the 5 classical tracer pesticides but also for other chemical classes of herbicides (chloridazon, isoproturon, metolachlor, ethofumesate and MCPP), fungicides (iprodione, metalaxyl, azoxystrobine, metconazole) and insecticides (cypermethrin).

Tracer active substances were loaded on each pilot system in the beginning of 2002 and in the beginning of 2004. The quantity was 20 g for biofilters and 40 g for phytobacs. Samples of elutes were collected during the 2002, 2003, 2004 and 2005 seasons and analysed for determination of pesticides residues.

Pesticides content was determined into elutes and therefore the efficacy (yield) of the systems was determined by measuring the balance of the inputs and outputs of the pesticides. The pesticides loaded from the biofilters users were also taken into account for the calculation of the efficacy by evaluating the pesticide wastes remaining in the tank.

$$\text{Efficacy (\%)} = (1 - \frac{\text{amount of a.s. losses}}{\text{amount of a.s. loaded}}) \times 100$$

Samples of substrates were also collected in the lower container of each biofilter and in phytobacs for pesticides residues and microbiological analysis in order to evaluate the degradation rate of pesticides into the substrate. The amount of active substance degraded was calculated on basis of the quantity of active

substances remaining into the biofilter, analysed into elutes and loaded onto the biofilter.

$$\text{Degradation (\%)} = (1 - \frac{\text{amount of a.s. in the substrate}}{\text{amount of a.s. loaded - amount of a.s. eluted}}) \times 100$$

The tracer pesticides in the elutes and the substrates were monitored using validated methods by Gas Chromatography with Mass Spectrometry Detection

(GC-MS) or by High Performance Liquid Chromatography with UV Diode Array Detection (HPLC-DAD).

Research Results

Efficacy of biofilters (retention of pesticides)

The figure 2 (add unit of Y axis – legend for red square?) represents for each pesticide analysed the total losses in elutes (mean of all biofilters and phytobacs) expressed as % of the total quantity loaded onto the system since the beginning of use until 2005. We can conclude that 75 % of biofilters have an efficacy (retention) above 90 % for all the molecules analysed and above 96 % for all the molecules except chloridazon, isoproturon and MCPP. For each active substance at least 1 system has an efficacy of 100 %.

The figure 3 represents for each biofilter and phytobac the average amount of active substance loaded onto the biofilter, the average amount and percentage of active substance lost in elutes. We can conclude that the efficacy for the mean of

all the pesticides analysed is above 87 % for all the biofilters and above 95 % for 16 biofilters on 20. The efficacy is good even with a high quantity of active substances loaded onto the biofilter (tested up to 12500 g for 4 years). Moreover losses of pesticides into elutes are rather well correlated with the treated volume.

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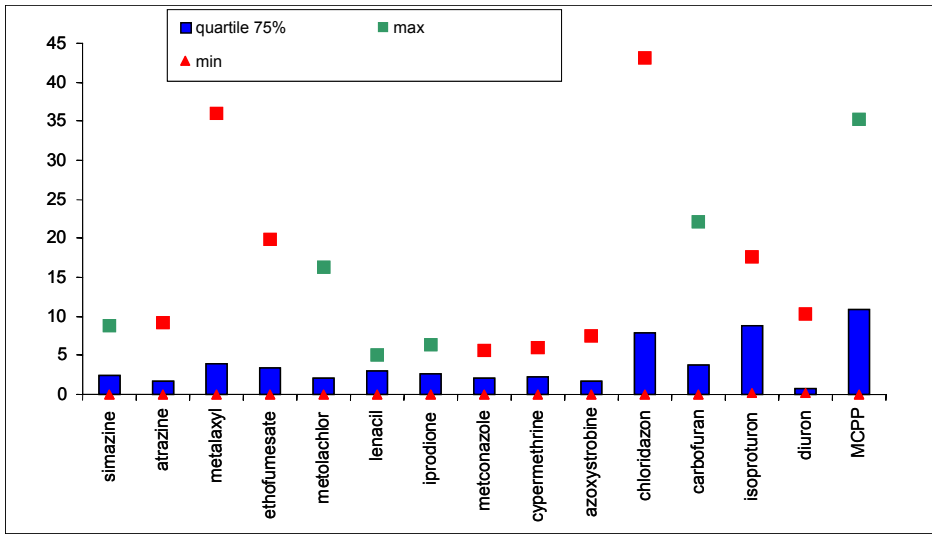
Figure 2. Total losses in elutes for each pesticide analysed (mean of all biofilters and phytobacs) expressed as % of the total amount loaded onto the system.
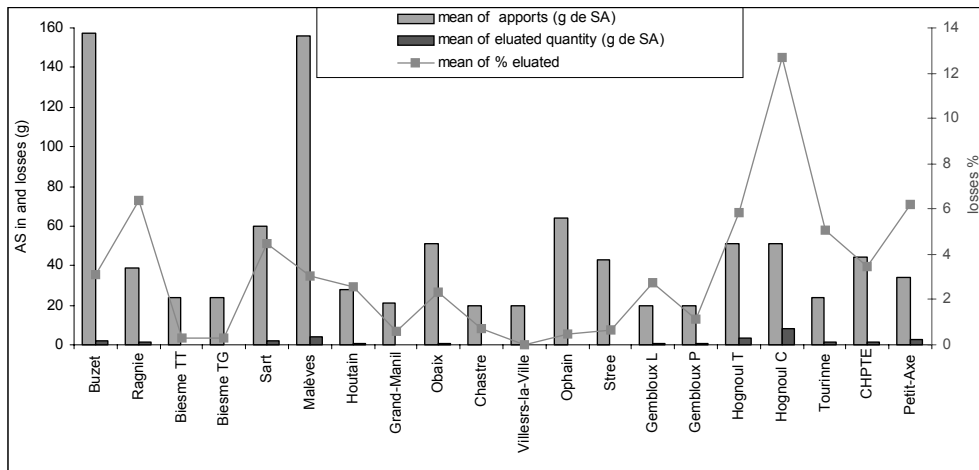

Figure 3. Average amount of active substance loaded onto the biofilter, average amount and percentage of active substance lost in elutes for each biofilter

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Degradation of pesticides into the biofilters

Substrates samples were taken in October 2004, February 2005 and September 2005 in the lower container of each biofilter or in the phytobac and were analysed for the determination of pesticides residues in order to evaluate the degradation rate.

We can conclude that for all the pesticides analysed in September 2005, 75 % of biofilters present a degradation rate above 91 %. If we consider the mean of pesticides in 75 % of biofilters, the degradation percentage is more than 98 %. We can also conclude that for all the biofilters in September, 2005 75 % of active substances show a degradation rate above 84 %. If we consider the mean of biofilters for 75 % of active substances, the degradation percentage is more than 96 %. These results demonstrate also that the degradation rate is increasing with time.

Discussion and Conclusions

Biofilters reduce highly the quantity of pesticides from rinsing and cleaning waters of sprayers. Considering the efficacy (retention) by pesticide, results obtained after 4 years of investigation for systems installed in 2002 and after 2 years of investigation for systems installed in 2004 showed that 75 % of biofilters have an efficacy above 90 % for all the pesticides analysed. This efficacy is above 96 % if we exclude chloridazon, isoproturon and MCPP. Considering the efficacy (retention) by biofilter (for the mean of all molecules analysed) results obtained after 4 years of investigation for systems installed in 2002 and after 2 years of investigation for systems installed in 2004 showed an efficacy above 87 % for all biofilters and above 95 % for 16 biofilters on 20. Losses of pesticides are rather well correlated with the treated volume. The good efficacy obtained after 2 years of use with herbicides was confirmed after 4 years of use with herbicides but also with insecticides and fungicides.

Concerning the degradation of pesticides into the substrate, the experiments carried out by analysing pesticides residues in the substrates sampled in October 2004, February 2005 and September 2005 have shown that the degradation rate

increases with time to reach a degradation percentage above 91 % for all the pesticides in 75 % of biofilters (above 98 % for the mean of all the pesticides analysed).

The results of the experiments show an overall good efficiency (retention) of pesticides by the biofilter and a high degradation rate for the majority of pesticides. Moreover the output water contains very low pesticides concentrations and do not present any phytotoxicity. Biofilters permit to collect and treat a high amount of pesticides from rinsing and cleaning waters of sprayers. This contributes significantly to the reduction of water pollution by pesticides.

Acknowledgements

EQUIPMENT

3D TEAT SHAPE MEASURING DEVICE BASED ON IMAGE ANALYSIS

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Keywords: Image analysis, teat, liner

Abstract

The teat morphology of dairy cows has an important impact on milking management and udder health and more specific on the choice of teatcup liner. Current measuring techniques for teat shape are time-consuming, not always very inaccurate and can lead to operator errors. In this study, a new device is proposed to acquire teat dimension parameters like teat length and teat diameters in order to calculate shape characteristics. The aim is to use a contactless measuring method to avoid any operator handling influence on the teat shape. A camera-based tool has been developed which provides accurate data, is easy to employ and is faster than existing measuring tools. Two mirrors are used to obtain a full surrounding view on the teat. From that information, a 3D model of the teat can be created with a a minimum resolution of 0.5 mm. From the 3D model several shape parameters can be calculated.

Introduction

The choice of teatcup liner for a dairy farm has a significant influence on the milking characteristics. Mein et al. (2003) reports that, depending on the type of teatcup liner, a six-fold differences in stripping yield, eight-fold differences in the incidence of liner slips and 33% differences in milking times between liner types were found. Rasmussen et al. (2003) concluded that the liner diameter should be

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slightly smaller than the teat diameter and that the length of the liner must be long enough with respect to the teat length in order to retain the collapsing effect of the liner underneath the teat.   Spencer et al. (1991) and Rogers et al. (1991) examined the relationship between liner slip with a given teatcup liner and teat morphology and they found that larger and wider teats tend to slip more.

In the past some tools to measure the teat morphology have been developed. Hamann and Mein (1988) described a spring-loaded caliper device, the cutimeter, a tool for the measurement of teat thickness. The measurement results should be treated with care since they depend on the applied pressure. Neijenhuis (2004) and Paulrud et al. (2005) used an ultrasonic scanner for measuring teat sizes. This method requires an experienced observer and is time consuming. Rønningen (2000) and (2007) demonstrated the "Teat Load Monitor" developed by Maalen-Johansen (1992). Itmeasures the teat dimensions on the outside of a teatcup liner during milking. Length measurements are often executed with a scaled transparent pipe.

The type of teatcup liner depends strongly on the teat morphology In practice, teatcup liners are frequently not adapted to the herd. A practical and fast measuring method to survey an entire herd's teats is until now not available. Existing measuring tools developed for scientific purposes are accurate but slow and difficult to use on a large scale base,. A fast and precise measuring tool for teat morphology would be a large step ahead for a well-founded choice of teatcup liners.

Material and Methods

A new teat shape measuring instrument should be accurate, operator independent, fast, practical in farm conditions and preferable contactless to avoid influencing the teat shape. A camera based instrument is elaborated in this study.

To obtain correct distance information out of an image, the camera-lens-combination should calibrated to avoid lens distortion, the objects distance and orientation to the lens must be known and the object must be identifiable out of the background. The setup has been designed to accomplish these three conditions (figure 1).
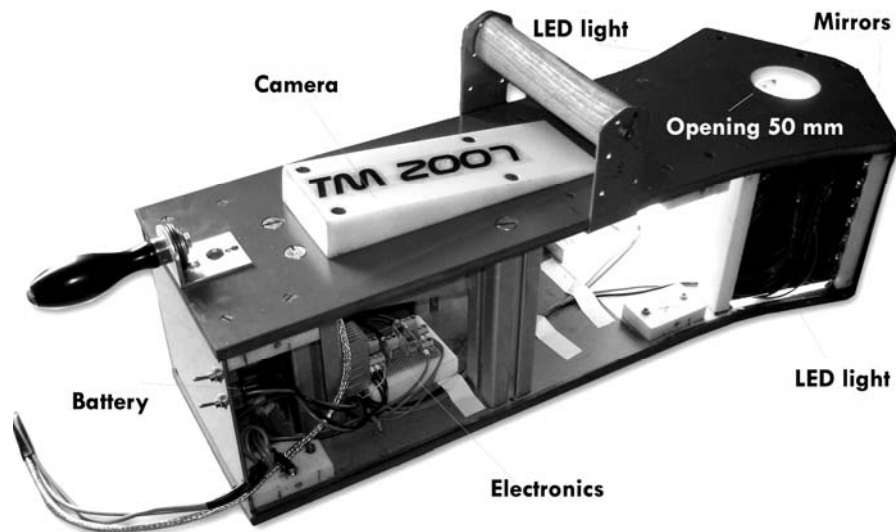
Figure 1. Vision based measuring tool for teat morphology

An AVT Guppy F-080C colour CCD camera with a 9 mm focal lens acquires the image of a single teat. The camera is calibrated with a 2D calibration plate to correct lens distortions and the Cartesian coordinate system is transformed into a spherical coordinate system for further calculations. Two front surface mirrors reflect the teats in the image with virtual viewpoints in angles of 120° and 240° relative to to the camera viewpoint. The exact orientation of the mirror planes is ?? calibrated with a 3D calibration grid. Two LED light sources are serve as background light for an optimal detection and separation of the contours of the teats by the image processing program. The housing is tightly sealed except for the opening to enter the teat. a previous study, (Baert,2007) concludes/proved that an opening of 50 mm was large enough to get the teat sufficiently deep in the picture for an adequate length measurement. To facilitates automatic analysis and to allow colour detection of the teat The teat is always captured under the same light conditions. . The housing contains a battery, which powers the instrument and the necessary electronics for stabilising the voltage of light source and the camera. A push button on the handle triggers the camera to acquire an image and flashs the LED lights. The images are sent to a notebook and analysed.

An image processing algorithm in Halcon (MVTec). performs the analysis. The software automatically calculates the length and three contours, each 120° rotated along the length axis, from which several diameters at different heights can be calculated. With the 1024 x 768 resolution camera, a resolution of 0.5 mm in real world coordinates is achieved. From the contours, a 3D model of the teat is reconstructed (figure 2).
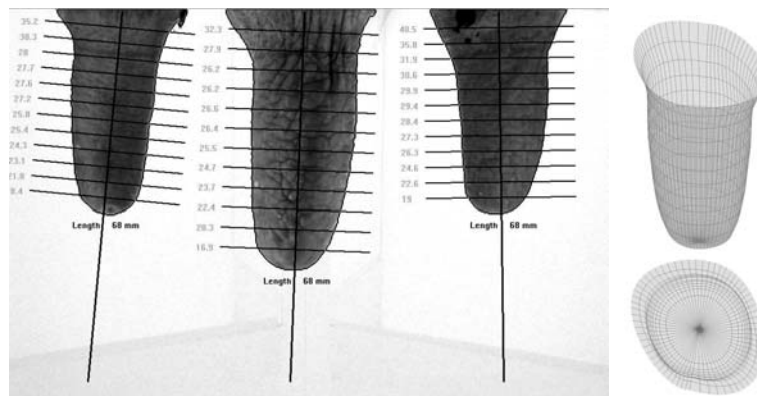

Figure 2. Automatic morphology determination of a teat and the reconstruction of a 3D model

Compared to the existing measuring devices, this system calculates the length and diameter at once. Furthermore, some extra information can be extracted from the image like curvature of the teat end, colour determination and the possibility for manually scoring the teat on the image.

Research Results

Measurements can be carried out at the feeding lot or more practical in the milking parlour. Most milking parlours are suitable for performing measurements with the above-described instrument except the side-by-side parlours because in the latter the teats are only accessible between the hind legs and this approach is often too narrow for the measuring tool. When the four teats are easily accessible the four measurements take less than 15 seconds. This makes it possible to survey a herd in pace with a milker in a milking parlour without interrupting the milking process.

The instrument has a resolution of 0.5 mm and is tested with an artificial teat with constant diameter on which a bulge of 0.3 mm was added. The instrument was able to detect the bulge of 0.3 mm.

Conclusion

The new teat measuring instrument is a fast and accurate tool with a lot of advantages over the other instruments available today. It will be used to create a large database of precise teat dimensions from dairy cows. The data on the breed, the lactation year, the lactation day and the position of the teat will be incorporated in a database. From this data, a statistical model will be built representing average teat size on dairy farm level. The ultimate aim is to compose a recommendation list with the best available fitting teatcup liner based on the average teat size. Other extractable features that can be integrated in the instrument's software are: colour of the teat, teat end condition and the curvature of the teat base.

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USE OF SUBSOIL IMPLEMENTS ON CHICORY HARVESTERS

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Keywords : chicory, harvesting, subsoil

Abstract

In Belgium, about 7000 ha of chicory are cultivated for inulin production. This plant possesses relatively long and sensitive roots and its harvest is fairly delicate as farmers aim for the entire and undamaged roots. Generally, modified sugar beet harvesters are used to lift the roots and remove the excess soil from the roots. To improve the quality of the harvested roots, some agricultural contractors have developed subsoil teeth. These teeth are placed at about 20 cm from the chicory rows and work at a depth of more than 20 cm to facilitate the lifting of the roots from the soil.

Experiments were carried out to define a suitable subsoil tooth profile and to assess the financial impact of the use of this equipment under different working conditions. Common harvesters, with and without, subsoil equipment were tested in different fields and under various conditions. Working conditions were identified (plant density, working speed, etc.) and samples of more than 200 roots were collected from each tested variant. The length, diameter and break diameter of the roots were measured. Using this data, the losses for broken roots can be estimated.

Initial results show that the subsoil tooth with a base plate offers better harvesting quality than the tooth with a cylindrical tip. However, the use of subsoil implement does not always give better results. A lower plant density (below 150,000

plants/ha), tends to yield bigger and longer roots and subsoiling leads to higher losses.

With subsoil implements, the working speed decreases by about 5 to 15% depending on field conditions and fuel consumption increases by about 10 l/ha. To compensate for the higher operating costs and the depreciation of the equipment the yield must increase with at least 200 to 400 kg/ha.

Finally, more tests are necessary to confirm the above observations and to measure the impact of subsoil equipment on ground tare content.

Introduction

In Belgium, about 7000 ha of chicory are cultivated for inulin production. This plant possesses relatively long and sensitive roots and its harvest is fairly delicate as farmers aim for the entire and undamaged roots. Generally, modified sugar beet harvesters are used to lift the roots and remove the excess soil from the roots. Actually, the losses during harvesting reach about 5 to 15 % with a great part due to the break of the end tip of the roots which remains in the ground.

Some years ago during a quite dry autumn in Belgium, some agricultural contractors decided to place subsoil teeth in front of their harvester in order to improve the quality of the harvested roots. These teeth are placed at about 20 cm from the chicory rows and work at a depth of more than 20 cm to facilitate the lifting of the roots from the soil (Figure 2). After this first experimental year, some contractors continued to use the subsoiler even in normal conditions.

Although theoretically the idea seems excellent, the shape of the teeth must be well designed in order to be efficient but actually the farmer uses home-made implements. Another point is that the harvesting conditions change from September to end November and in some conditions subsoil implements seem to have a negative influence on the yield or are simply impossible to use when the conditions are too bad.

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We present in this paper some experiments to compare different subsoil teeth profile and the impact on the yield when using this kind of equipment. Finally, a short economical analysis defines the necessary increase in the yield to cover the higher harvesting costs.

Figure 2. View of the subsoil implements on a chicory lifter.

Materials and methods

In 2007, a first experiment was planned on a test field of ORAFTI to define a suitable subsoil tooth profile. Three harvesting techniques were compared: a sharp-pointed subsoiler tooth, a newly developed goosefoot-shaped tooth, and no subsoiler. The specific design of the second subsoiler type (Figure 3**Erreur ! Source du renvoi introuvable.**) was developed based on ORAFTI's extensive experience and insights in chicory harvesting. The teeth were drawn by means of CAD software and constructed in the ILVO workshop.
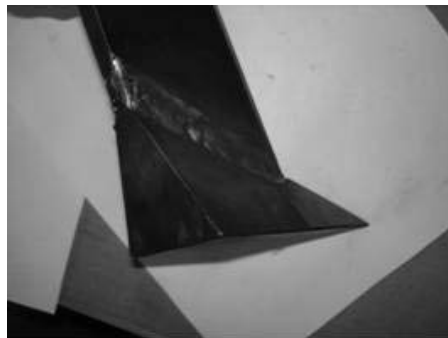
Figure 3. ORAFTI's specific design of the subsoiler type.

Each type of subsoiler should be tested under dry, normal and wet soil conditions. Due to bad weather conditions in 2007 no tests were carried out under dry and normal soil conditions. For this field experiment two times six rows were harvested using each technique (Figure 4**Erreur ! Source du renvoi introuvable.**). Subsequently, of each swath, five samples of 40 roots were taken. Thus, for each technique 400 roots were collected. Root length, head diameter and breaking diameter (Figure 5) were precisely measured of each root.

The data were statistically processed using a nested Anova technique in the Statistica software.
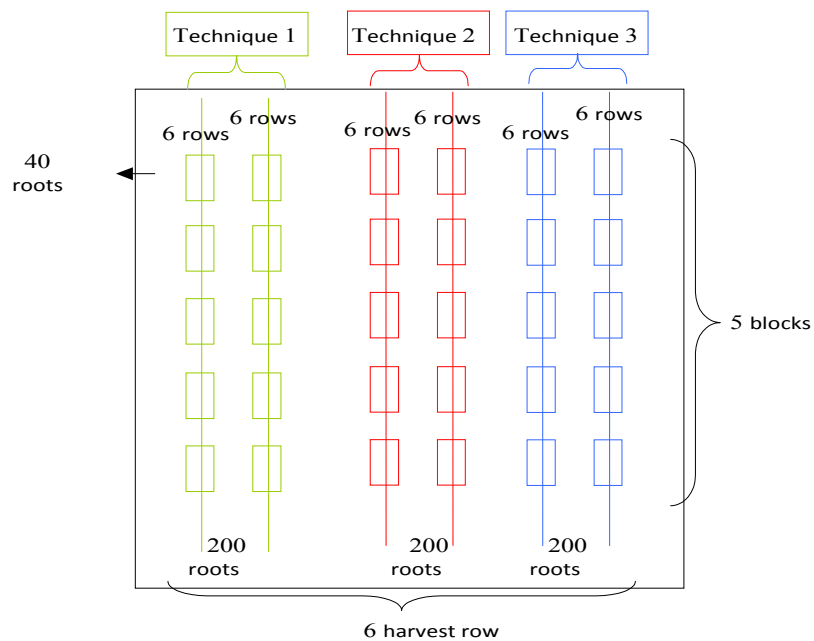
Figure 4. Field set-up
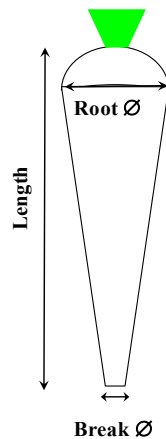
Figure 5. Illustration of the measurements made on the chicory roots.

Others experiments were carried out to assess the financial impact of the use of this equipment under different working conditions. Common harvesters, with and without, subsoil equipment were tested in different fields and under various conditions during the autumn. Working conditions were described by :

- plant density which is measured by counting the plant on a distance of min 10 m at 5 places on the field where the tests are happening.
- working speed of the harvester which is measured by knowing the time to drive along min 50 m.
- size of the roots which is determined by measurement of the length and diameter of sampled roots.
- ground state (humidity, compaction, …).

In order to compare the influence of the subsoil implement on the harvest process, samples of more than 200 roots were collected from each tested variant. The length, diameter and break diameter of the roots were measured. Using this data, the losses for broken roots can be estimated using a formula proposed by the Agricultural Centre Beet – Chicory [1995].

Research Results

For the first experiment the influence of the technique on the break diameter was tested showing a significant effect. Figure 5 shows no difference between the sharp-pointed subsoiler tooth and newly developed goosefoot-shaped tooth but the break diameter is significantly smaller for the third case were no subsoiler is used.
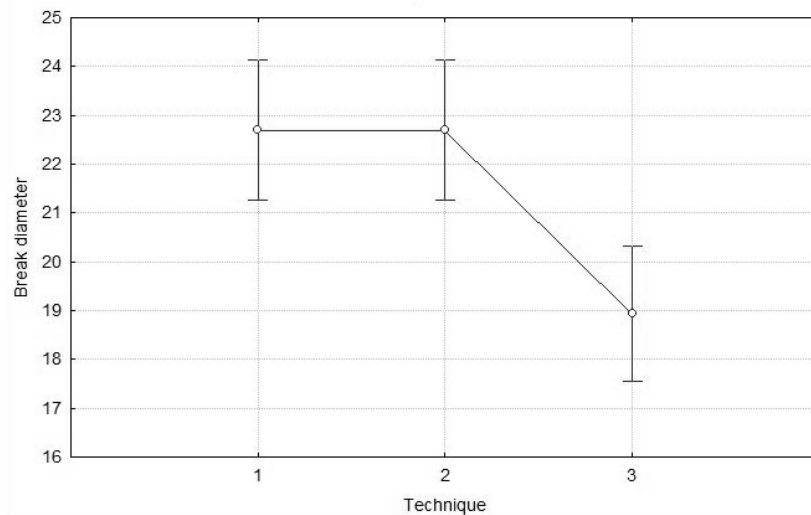

Figure 6. Effect of the three techniques on the break diameter of the roots

The effect of the technique on the length of the roots is analyzed as well. Figure 6 indicates that using no subsoiler gives the best results. In these cases the second and the third technique are significantly different from the first.
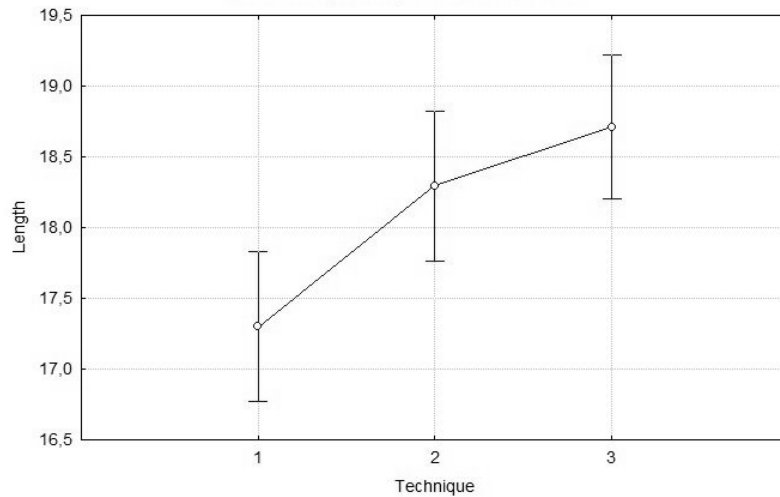
Figure 7. Effect of the three techniques on the length of the roots

More than 10 tests were carried out under different field conditions from September to end November. For each of these, we compared on the same field under identical conditions, the quality of the lifted roots when the harvester was working respectively with or without subsoil implements.

In average, we observe that the losses are reduced by about 600 kg/ha when using subsoil implements (Figure 8). The utilization of the subsoil reduces the break of the end tip of the roots by about 0.25 mm which leads to an increase of 0.9 cm in the roots length.
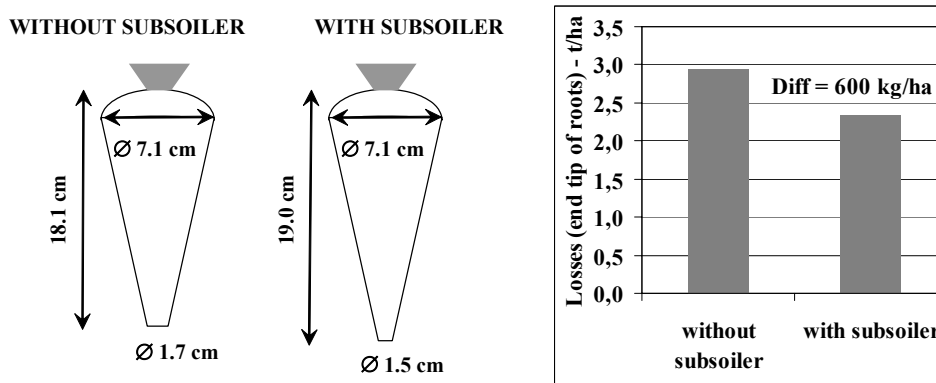
Figure 8. Average roots dimensions – Average losses due to end tip break of the roots.

However, the use of subsoil implement does not always give better results (Figure 9). In our observations when using subsoil equipment, the influence on the losses can vary in a large way ranging from an increase of 0.6 t/ha to a reduction of 1.5 t/ha. Previous tests had shown that a lower plant density (below 150,000 plants/ha), tends to yield bigger and longer roots. In this situation, subsoiling leads to higher losses. We observe a situation where the plant density was high but with an increase of the losses when using subsoiler. In this particular situation, the roots were very short due to a high compaction of the ground at about 15 – 16 cm depth. The subsoil teeth have probably broken the roots with the displacement of the compacted soil.
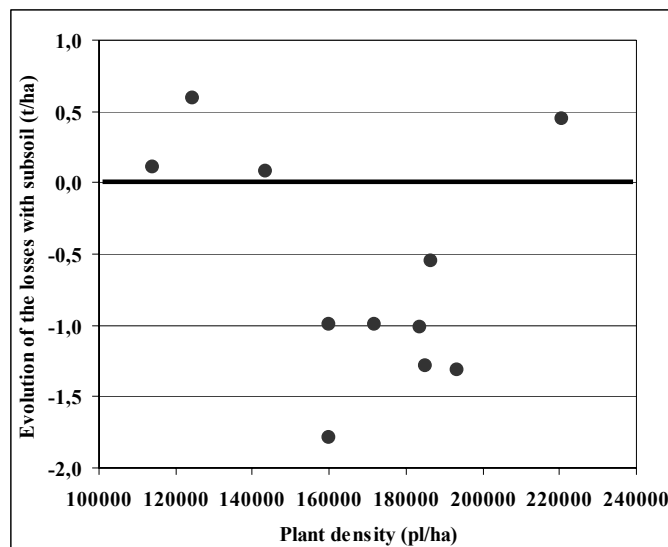

Figure 9. Evolution of the losses when using subsoil implement in function of the plant density.

With subsoil implements, the average working speed decreases from 3.7 km/h to 3.5 km/h which represents a reduction of 5 % (Figure 10). This impact depends on field conditions and we observe more important speed reduction up to 10% in wet conditions. Fuel consumption increases by about 10 l/ha, due to the performance reduction and higher traction power needs. Finally, subsoil implement represents an investment of about 2500 € that can be amortized during 10 years. In first approach, we can calculate an increase of the harvesting costs between 9 and 15

€/ha (Table 3). To compensate for the higher operating costs and the depreciation of the equipment the yield must increase with at least 200 to 350 kg/ha.
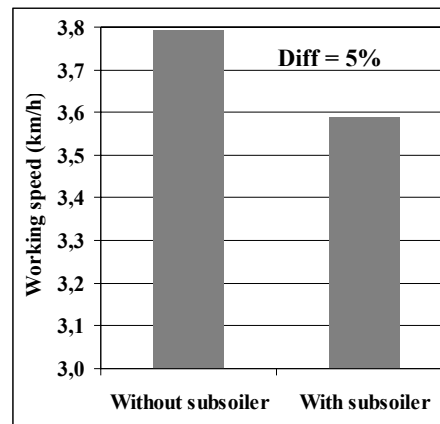

Figure 10. Comparison of the working speed with or without subsoiler.

Table 3. Details of the increase of the harvesting costs when using subsoil implement.

Fuel consumption increase (€/ha)	5					
Working speed reduction	5%			10%		
Labour cost increase (€/ha)	2.5			5		
Yearly utilization (ha/year)	50	100	150	50	100	150
Depreciation (€/ha)	5	2.5	1.7	5.0	2.5	1.7
Total (€/ha)	12.5	10.0	9.2	15.0	12.5	11.7
Equivalent chicory quantity (kg/ha)	278	222	204	333	278	259

Discussion and Conclusions

In average, subsoil implement has a positive influence on the harvested yield thanks to a reduction of losses caused by the breaking of the roots end tip. We observe an average decrease in the losses of about 0.6 t/ha.

But various factors can change this situation and sometimes lead to an increase of the losses.

The first one is the design of the subsoil teeth (shape, working depth, position, …).

When comparing different subsoiler designs, harvesting with subsoiler teeth did not yield better results than without subsoiler teeth. Also, the new design teeth showed no improvement compared to existing models. Similar conclusions could be reached from the root length and break diameter. The disappointing results can be explained by the adverse harvesting conditions. Based on the results of this test it seems that under wet conditions subsoilers should not be used.

The field conditions have also a major influence on the final result. When the plant density is lower, the roots are bigger and longer. In this case, subsoil implement can provoke higher break of the roots end tip.

On an economical point of view, subsoil implements lead to a reduction of the working speed and to an increase in the fuel consumption. To compensate for the higher operating costs and the depreciation of the equipment the yield must increase with at least 200 to 350 kg/ha.

Finally, more tests are necessary to confirm the above observations and to measure the impact of subsoil equipment on ground tare content.

Acknowledgements

MACHINE USE on SELECTED POLISH FARMS

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Key words : mechanization, farms, machine utilization

Abstract

The aim of this study was to analyse machinery use on selected farms in Poland. A hundred farms were selected in the region of Lower Silesia and information was collected during interviews with the farmers. Descriptive statistical methods were used for data processing.

From the analysis it appears that individual use of machinery largely outweighed collective use. A small part of collective machine use had a very local character and was restricted to the neighbourhood. Questionnaires (returned by the farmers) on the various forms of machine utilization were carried out. A large majority declared that all the machines were their property. The farmers defended their choice for individual use based on the timely availability of the machines, the quality of the work delivered and on careful servicing to maintain the machines in good technical state.

Introduction

Forms of machine utilization at Polish farms and the quality of the work carried out contribute in determining the costs of mechanization (Karwowski, 2005). Several investigations demonstrate the superiority of shared use of machinery over individual use (Muzalewski, 2002). Sharing machinery results not only in minimizing the exploitation costs but also leads to an improvement in the quality of the performed work with modern equipment (Pawlak, 1998). However, sharing

machinery is not particularly popular in Poland. The aim of this study was to analyse the form of machinery use on selected farms in Poland (Olszewski, 2000).

Materials and Methods

The research was performed in 2008 in the Lower Silesia Region of Poland. A hundred farms were selected and information was collected during interviews with the farmers. Descriptive statistical methods were used for data processing (mean, variation coefficient). Common usage of machinery wasn't noted. In all farms the major form of usage was own equipment with a different share of services. So the farms have been divided in four groups:

A – own equipment only (20 farms),

B – own equipment and output services (12 farms),

C – own equipment and input services (40 farms),

D – own equipment and output services and input services (28 farms).

In these groups the characteristics of the most important machines and opinion about their utilization forms has been analysed.

Research Results

The main profile on all farms was plant production. Animal production was not significant as demonstrated by stock density of about 0,13 LU/ha UAA in the A group and 0,21 LU/ha UAA in the D group. In arable farming, cereals was the major crop with about 69% in the A and B group. Average farm size in UAA was: 53,71 ha in group A; 72,64 ha in group B; 42,71 ha in group C; 62,86 ha in group D. In all groups the average number of tractors was at least2. The highest numbers of tractors per 100 ha were noted in the A and C groups. This ratio is too high since tractors in these groups are only used for own purposes. Also in these groups the lowest yearly utilisation of tractors was noted with a higher running cost as consequence. In all groups the average age of tractors was about 20 years.

Table 1. Characteristics of tractors

No.	Specifications	A	B	C	D
1.	Power [HP]	70,87 (37,85)*	75,17 (31,24)	69,90 (28,23)	76,44 (28,50)
2.	Age [years]	19,30 (35,16)	20,58 (24,79)	21,38 (32,55)	19,90 (44,11)
3.	Expected time of further usage [years]	7,86 (63,66)	7,74 (52,50)	7,90 (53,05)	8,01 (45,59)
4.	Yearly utilisation [h]	394,61 (57,97)	482,40 (53,12)	421,64 (85,29)	466,10 (87,09)
5.	Age at time of purchase [years]	6,37 (83,63)	7,92 (72,58)	7,40 (116,38)	7,04 (126,06)

Source: own calculations ; *- variability coefficient under each data

The highest density of combines per 100 ha was noted in group A, with a low yearly utilisation of 90 hours. Only in group D the utilisation was optimal. Sugar beets and potatoes covered marginal surfaces of UAA from 4 to 10%. The majority of beet and potato combines was purchased if the share of these plants was higher.

This is the reason for the relatively higher usage ratios of these machines with a low yearly utilisation. In most cases these machines are one or two rows harvesters with low exploitation efficiency.

Table 2. Characteristics of combines

No.	Specifications	A	B	C	D
1.	Age [years]	23,29 (31,57)*	21,58 (27,97)	22,82 (37,12)	19,11 (37,38)
2.	Expected time of further usage [years]	7,44 (45,79)	5,82 (48,50)	8,00 (28,87)	8,41 (44,09)
3.	Yearly utilisation [h]	87,63 (78,63)	95,00 (50,18)	97,45 (55,58)	189,12 (119,83)
4.	Age at time of purchase [years]	11,28 (76,51)	14,00 (64,03)	12,70 (53,41)	13,06 (48,86)

Source: own calculations; *- variability coefficient under each data

Table 3. Characteristics of sugar beet harvesters

No.	Specifications	A	B	C	D
1.	Age [years]	20,00 (18,71)*	26,67 (20,65)	25,20 (30,66)	20,75 (19,82)
2.	Expected time of further usage [years]	8,75 (85,71)	7,33 (51,63)	2,83 (64,76)	6,00 (44,10)
3.	Yearly utilisation [h]	72,50 (39,62)	83,33 (42,14)	75,00 (82,95)	46,25 (69,15)
4.	Age at time of purchase [years]	8,50 (68,26)	13,33 (33,82)	8,00 (94,37)	12,75 (77,21)

Source: own calculations; *- variability coefficient under each data

Table 4. Characteristics of potato harvesters

No.	Specifications	A	B	C	D
1.	Age [years]	22,71 (32,92)*	19,67 (15,53)	17,25 (35,85)	18,83 (30,85)
2.	Expected time of further usage[years]	7,63 (33,57)	6,33 (39,74)	6,25 (40,00)	7,71 (35,61)
3.	Yearly utilisation [h]	42,50 (75,05)	121,00 (156,90)	55,00 (67,22)	67,67 (168,61)
4.	Age at time of purchase [years]	6,83 (199,03)	2,67 (114,56)	6,67 (173,21)	3,83 (147,95)

Source: own calculations, *- variability coefficient under each data

The analysis of equipment shows that, in all selected groups, farmers use old machines, often exceeding 20 years of age.

Often the equipment was purchased as a second-hand. In most cases the machines are technologically and technically obsolete and there is a need to replace them with modern models.

These are relatively few possibilities of using machines, especially in groups A and C and this creates an economic limit for purchasing machinery.
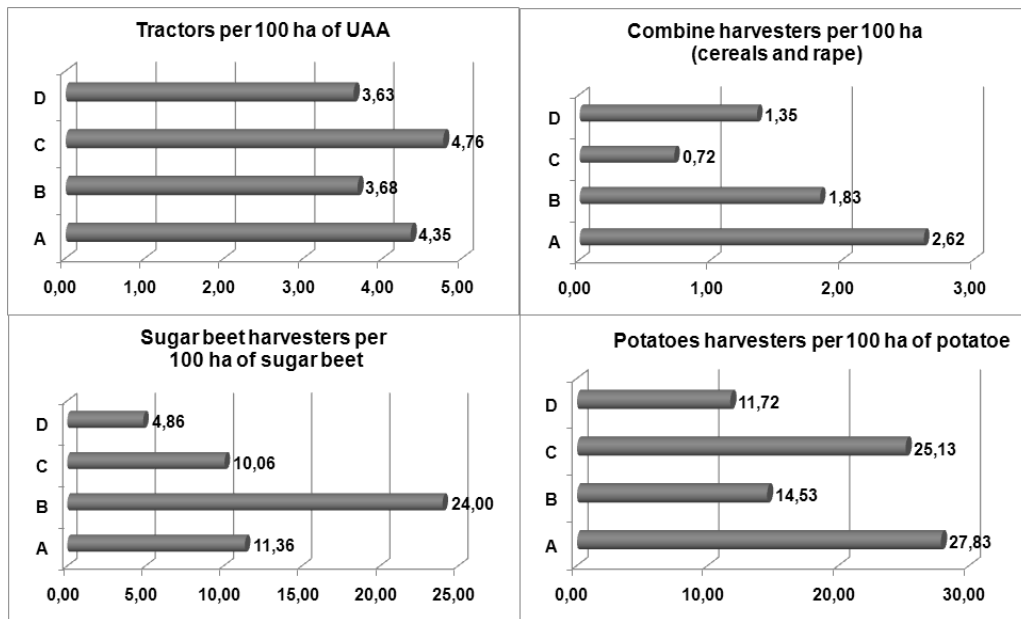
Fig. 1. Level of tractor and combine equipment ratios.

An increased level of yearly usage can be achieved by additional services and sharing more important machines. The analysis of the questionnaires completed by the farmers with regard to machinery usage confirms that most machinery belongs to the farmer and is not shared.

This opinion is shared by 90% of the farmers in group A, 75% in group B 69% in group C and 57% in group D. Higher values for sharing machinery were noted in groups B and D. Each fifth farmer in group C confirmed using of services as the

most profitable form. This point of view does not apply for using highly effective and modern machines in spite of the relatively large acreages. They will only be able to buy second-hand machines which do not always guarantee proper quality and work comfort. It seems that buying new tractors and machines, groups A and C is unreasonable.

Detailed information from the range of the most profitable methods of using machines by farmers is presented in figure 2.
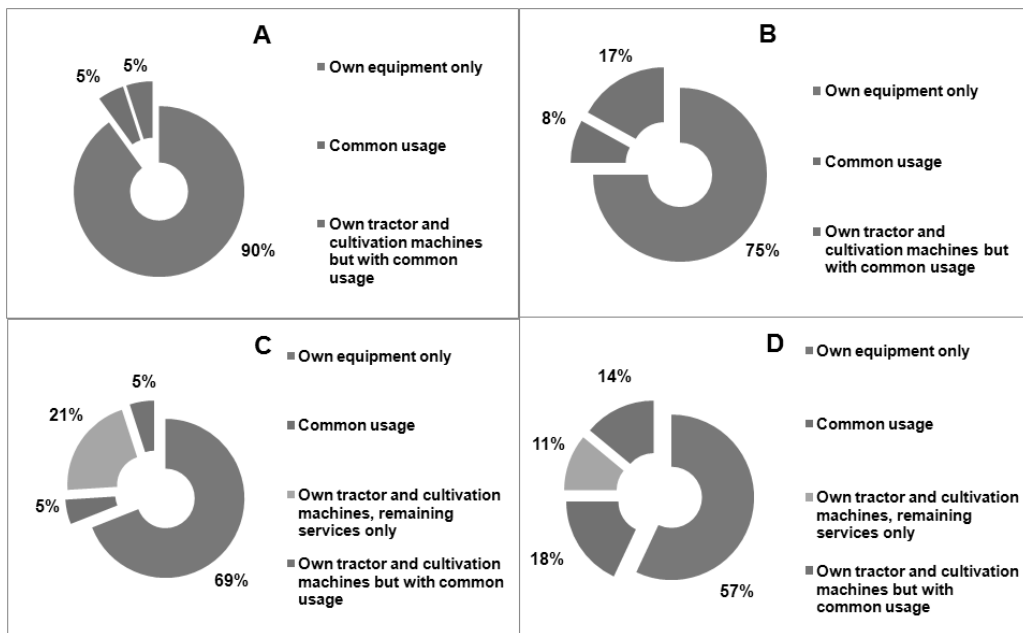
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Fig. 2. Farmers opinion on the various forms of machine utilization

Conclusions

- From the analysis it appears that individual use of machinery largely outweighs collective use.

- A small part of collective machine use had a very local character and was restricted to the neighbourhood.

- The individual use of machinery leads to low yearly utilization.

- Evaluation of the machine park confirmed that the machinery was technically and technologically obsolete.

- The study confirmed that the questioned farmers had no intention to alter the form of machine usage.

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EFFECTS OF THE THRESHING UNITS TYPE ON THE YIELD OF SWEET MAIZE GRAINS

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Keywords: sweet maize, threshing, freezing, sieve analyses, separation

Abstract

The aim of this research was to perform a comparison between three various types of thresher units used to separate sweet maize grains from the cob regarding the yield and the sieve analysis. Before threshing the sweet maize cobs were blanched in water and frozen in liquid nitrogen. The measurements were taken for different threshing speeds. The yield of threshed grains was determined and the sieve analysis was performed afterwards. It was found that the type of thresher unit and threshing speed have significant statistical effects on the evaluated parameters. The highest mean values of the parameters were achieved for the strip-type (ZL), and the lowest ones for the disc-type (ZT). A rise in the yield and the 8 mm fractions of corn grains was observed with increasing the working speed of the processing unit

Introduction

Commercially, the most common method to separate maize grains from the cob consists in cutting the grains with a sharp blade. Unfortunately, it is not possible to obtain whole grains of maize; the cutting operation severs the upper part of the grain from the lower part which remains on the cob (*Riad and Brecht, 2001, Niedziółka et al., 2003*). Thus, the hull of the grain is broken open and part of each grain is wasted including much or all of the germ of the grain (*Robertson et al., 1977*). Furthermore, during subsequent wet-processing, including washing and blanching of the severed grains, part of the maize meat is leached from its pouch

and lost (Robertson *et al.*, 1979; Love, 1990). Not only is this loss economically detrimental, but a significant pollution problem is created. The new alternative method for separation of grains from the cob produces the desired intact grains by rapidly freezing the grains on the cob in a liquid cryogenic freezant to a depth not exceeding the abscission layer. The frozen cob is then subjected to impact in a conventional field-maize threshing device whereby intact grains are separed from the cob. One advantage of this method is the reduction of waste and increased yield of maize. Another is that none of the germ or heart of the grain is lost.

Analyse of literature showed that the published studies on shelling frozen cobs to produce canned or frozen sweet corn are scarce. *Domin and Kluza* (*2005*) performed threshing tests on pop maize with grain moisture about 15% under temperature of grain between 17.0 and -38°C. However the threshing of maize grains at 15% moisture level is also possible without cobs frozen. *Nkakini et al.* (2007) reported that qualitative threshing is difficult to achieve at a moisture content of the grains exceeding 25% (w.b). In case of fresh sweet maize the moisture is above 70%.

The objective of this study was to perform a cross-comparison between three various types of the thresher units regarding grains separation rate and sieve analyse.

Material and Methods

In these tests, the cobs of sweet maize of cultivar Candle were used The cobs for the study were manually harvested from random locations in the plantation during the late-milk ripeness phase. The maize cobs selected for the tests were healthy, straight in shape and had a high degree of grain filling.

Before threshing, sweet cobs were blanching and frozen. Blanching was carried out in a vessel containing about 15 dm^3 of water and electrically heated Each portion containing 10 pieces of sweet maize cobs placed in a metal basket and submerged in water at 85 °C for 2 minutes *(Chobpattana, 1994)*. Then the cobs were cooled in

a cold-water to about 20°C and air-dried using a fan. The cobs were then frozen by spraying liquid nitrogen from the Dewar flask through a withdrawl device for 6 minutes periods at a temperature of circa -120 °C.

The threshing was done with three different types of threshing unit: classical beater-type (ZC), strip-type (ZL) and disc-type (ZT). The maize thresher was operated with a cylinder (disk) speed from 90 to 130 rad/s for ZL, from 40 to 80 rad/s for ZC and from 70 to 110 rad/s for ZT. Once the thresher was stabilized at the desired speed 60 maize cobs were fed continuously through the hopper. The grains that had been separated from the cobs were weighed. The remaining grains still attached to the cobs were manually threshed and weighed. All tests were performed on the same date the maize ears were harvested from the experimental plot. The sieving test was conducted for four sizes: m_1 -8; m_2 - 6; m_3 - 4 and m_4 - 2 mm. The experiments were replicated thrice in 500-gram samples for each threshing speed and the average values were reported.

The grains separation rate (KSR) was determined according to *Szymanek (2008)*.

Mesh fractions (m_i) and their percentage share (x_i) were determined by formula:

$$x_i = \frac{m_i}{m} \cdot 100 \quad [\%] \tag{1}$$

where:
m – initially mass of maize grains

Data were subjected to analysis of variance (ANOVA). Comparison of means was conducted with Tukey's least significant difference (LSD) test, at a significance level p = 0.05.

Results and Discussion

Grains separation rate
Tests were carried out on the three kind of maize threshers to determine mean values of the grains separation rate and sieve analysis (see Figures 2-4).
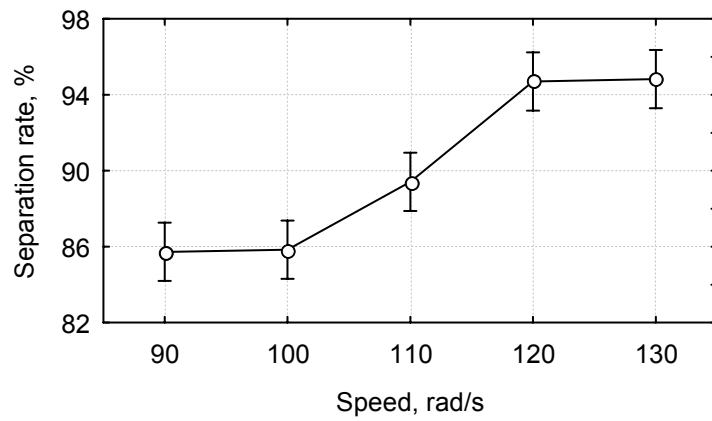
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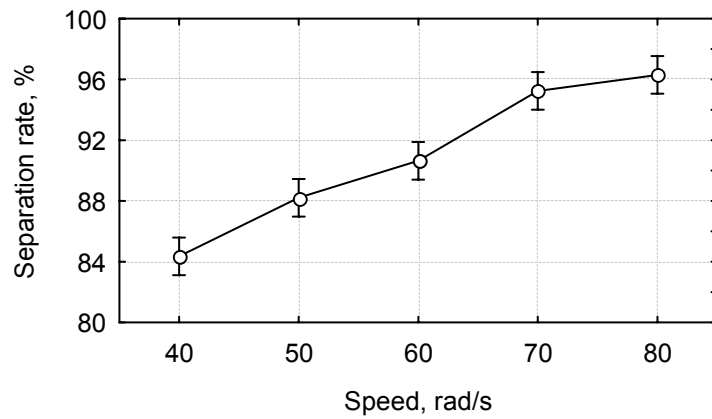Fig. 2. Mean grains separation rate for the ZL

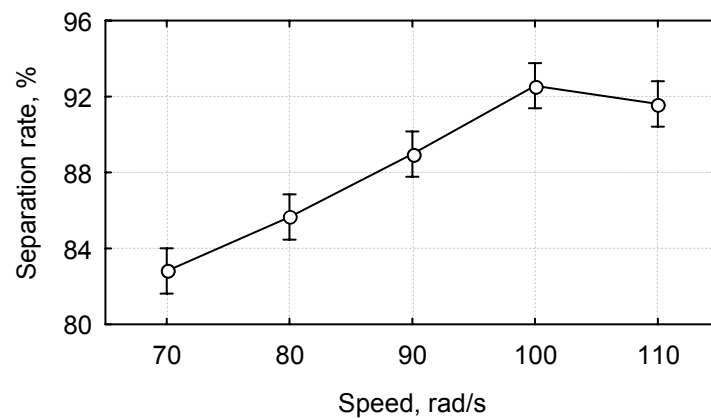Fig. 3. Mean grains separation rate for the ZC

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Fig. 4. Mean grains separation rate for the ZT

Figures 2-4 show that the KSR increases with increasing threshing speed. The KSR determined as a function of threshing speed ranged from 85.7 to 94.8 % for ZL, from 84.3 to 96.23 % for ZC and from 82.8 to 91.8% for ZT. Similar results were found by *Domin and Kluza* (*2005*). They found that the effects on the reduction in threshing losses, depend on the type of maize variety, between 14.60 and 1.36%, and on the decrease in grain damage by 8.21 and 0.86.

The sweet maize moisture content appears to be a less significant factor influencing KSR. The own study showed that the time of freezing was a more significant factor influencing KSR. This factor effects hardness of grains.

Sieve analyze
The mean values of share of the grain fractions screened on sieves with hole-sizes of 8; 6; 4 and 2 mm ranged from 88 to 1% for the ZL; and from 83 to 2% for the ZC; 68 to 3% for the ZT (Fig. *5*).
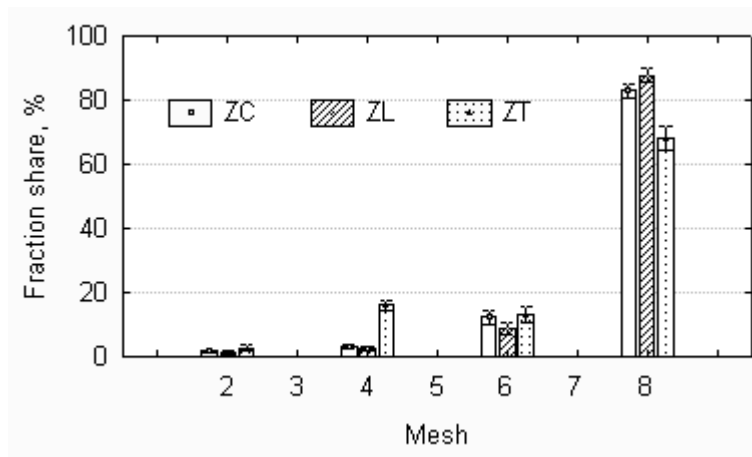
Fig. 5. Fractions share (x_i) in dependence of sieve mesh

Fractions share were not significantly different between ZL and ZC. The lowest fractions share on sieve with hole-size of 8 mm for ZT, is due to the working principle of this kind of thresher unit.

Conclusion

1. The kind of thresher unit influences as quantity as well quality of separated sweet maize grains. A rise in the yield of maize grains was observed as the threshing speed grew and in line with the share of the grain fractions on sieves with the largest hole-sizes.
2. The highest values of separation rate were obtained for beater-type at and the lowest for disk-type thresher units.
3. The important implication of the results of this study is that each of maize thresher can be used to thresh frozen sweet maize.

Acknowledgements

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