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# Comparison between traditional and reduced grain production technologies with consideration to the technical equipment evaluation

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**Abstract:** *Comparison between traditional and reduced grain production technologies with consideration to the technical equipment evaluation.* There are presented results of comparison between grain production technologies that are different in respect of approach to the tillage stage. The scope of investigations covers the factors that shape economic effectiveness of grain production, with the use of conventional technology (including ploughing) and reduced technology (with application of direct drilling). Basing on the determined direct surplus and other economic indices there are presented differences in the application effects of compared tillage systems. There are presented results of evaluation of various tractor combinations with the selected tillage outfits.

*Key words*: effectiveness, costs, grain production, technique, technology

## INTRODUCTION

In Polish agriculture the cereals take about 75% of crops in recent years. In respect of growing demand for cereals and their increasing yield, the interest in their cultivation is growing [Seremak-Bulge Ed. 2013]; it is an incentive towards undertaking economic analyses in the field of grain production.

The economic calculus help the producer in undertaking decisions that enable to optimize agricultural production in the defined conditions [Harasim 2012]. The economic analyses point out that many farms (including plant production farms) have problems in reaching sufficient incomes to secure own financial needs. In particular, these problems concern the small grain-producing farms. Investigations point out that the unitary profitability of agricultural production decreases. Whereas the parity income in 1990 was obtained by farms of area 10 ha, at present the farms of area 70 ha and more not always manage to reach income that allows for farm development under defined conditions [Grabiński 2011]. Therefore, increasing the farm area remains one of development directions.

The next problems concerning the large and very large grain-producing farms result, first of all, from similarities in growth and development biology of cultivated crops. It forces to perform particular agro-technical operations on large areas and in the short time; it is very difficult especially in years of unfavourable weather. The possible delays generally result in adverse effect in the yield and its quality. A positive role can have here selection of proper plant species and varieties. Therefore, the bigger farms specialized in grain production must invest in more productive equipment that enables to execute particular

production technology elements in possibly short time, as well as to apply the reduced tillage [Grabiński 2011].

Modern technique is one of the main factors that assure stable yield and appropriate agricultural income. Proper selection of machines and their utilization significantly affect good soil preparation for sowing, thus, obtaining the required crop density, maintaining good state of plantation and harvesting of entire yield. The modern machines are more efficient, they reduce the specific costs and energy inputs, as well as the time of a given operation execution.

This work aimed at comparison between economic indices that characterize the traditional and reduced grain production technologies, with particular consideration to tillage operations and evaluation of tractor outfits selection for the farm.

## MATERIAL AND METHODS

In economic analysis of investigated technology there were taken into account the material and raw material costs, exploitation of machines and equipment, the consumed fuel and labour costs. According to guidelines [Stelmach and Maciejewski 1982] there were used data concerning materials, consumed fuel, labour costs etc., included in book entries of the farm.

The undertaken investigations aimed (from economic point of view) at determination of direct surplus as an effect of selected grain production, with the use of tillage traditional technology (including ploughing) and the reduced technology. The calculus of direct surplus made in the farm is used in analysis of economic activity and enables to evaluate the obtain production results.

The direct surplus of a given agricultural activity is the annual production value obtained from 1 ha of crop, less direct costs of this production. The production value of a given activity is the sum of main products and by-products that are present in circulation of commodities and is determined according to the sale prices.

A set of direct costs that decrease the production value varies in the plant and animal production. Components of direct costs coming from outside the farm are determined according to purchase prices, while components of costs created inside the farm (sowable material) according to sale prices.

The economic analysis of grain production carried out with consideration to high variability of means of production prices, labour costs and agricultural products' prices allows for economic evaluation of proposed technologies.

The investigations were carried out taking an example of farm oriented towards production of grain and leguminous plants, of area about 54 ha on the soil of various valuation classes. The investigated winter triticale was cultivated on area of 32 ha; it made about 63% of total plant production acreage on arable land in the farm.

## RESULTS AND DISCUSSION

The results of direct surplus calculations for winter triticale cultivated by traditional method (including ploughing) and by reduced cultivation (with direct drilling) in the season 2011/2012 are present-

ed in Table 1. In economic analysis of investigated technology there were used data included in book entries of the farm: material and raw material costs, costs of machine and equipment exploitation, costs of consumed fuel and labour costs. No additional payment that the farm receives directly for plant production was considered in the list [Balcerzak 2012].

High yield that satisfies the producers calls for execution of appropriate operations of the high technical level and the connected higher and higher inputs, especially in soil tillage and plant fertilizing. At the same time, the economic situation in agriculture varies, mainly due to fluctuations in prices and continuity of additional payments. Therefore,

TABLE 1. Direct surplus in winter triticale production depending on assumed technological solutions

| Item | Grain production technology with | |
|---|---|---|
| | ploughing | direct drilling |
| Yield [dt/ha] | 65 | 54 |
| Value of production [PLN/ha] | 5,200 | 4,320 |
| DIRECT COSTS [PLN/ha] | | |
| Sowable material [PLN/ha] | 200.00 | |
| Mineral fertilizers [PLN/ha] | 278.00 | |
| Plant pesticides [PLN/ha] | 162.00 | 216.00 |
| Operation of tractor outfits [PLN/ha] | 1,114.26 | 557.13 |
| Grain harvesting with combine [PLN/ha] | 560.00 | 560.00 |
| Total direct costs [PLN/ha] | 2,314.26 | 1,811.13 |
| DIRECT SURPLUS [PLN] | | |
| per 1 ha | 2,885.74 | 2,508.87 |
| per 1 PLN of direct costs | 1.25 | 1.39 |

Source: own elaboration.

It is evident from comparison between the indices presented in Table 1 that implementation of direct drilling technology was accompanied by the lower value of direct surplus, when compared to traditional tillage system with ploughing. Although application of direct drilling caused a decrease in total costs of technical equipment exploitation, it did not compensate the lower income of the grain sale. The lower income resulted from the lower grain yield obtained in winter triticale production with direct drilling technology.

agricultural activity is the field of searching for alternative solutions, e.g. searching for savings (also in tillage), as well as modernization of farm machine fleet.

Observing changes that occur in agriculture for several years (mainly in large farms) one can find distinct changes in the applied methods for soil cultivation [Kalinowska-Zdun 1997]. Tillage machines of low output are used less frequently; they are replaced with the machines of substantial working widths, often multifunctional ones, due to their output, and savings in energy and financial inputs [Dobek 2003].

The traditional tillage with application of a plough still remains the most common soil cultivation system. It includes the multiple penetration of the soil top layer during a year, while ploughing is a basic operation accompanied by a series of secondary tillage operations as harrowing or disking. Its main advantage is good coverage of crop residue and loosening of the soil top layer. Among the key disadvantages one can find destruction of natural soil protection layer and its structure, disturbance of the nutrients circulation, enhancing of water and wind erosion and too fast decomposition of organic matter. Besides, this system is characterized by high time-consuming and energy-consuming and also low productivity of operations [Orzech and Marks 2010].

Although no financial advantages resulted from implementation of grain production technology with direct drilling were confirm by the results of investigations, a series of advantages of the reduced soil tillage should be underlined, in respect of not economic aspects. One of them points out at measurable benefits in the field of organization, namely the lower labour inputs and time savings. The other advantages include: reduced fuel consumption, lower number of machines and lower costs of their maintenance and service [Labereuche 2007].

Taking into consideration a key role of tillage operations in the compared grain production technologies, in the second part of analysis there were amplified the selected aspects of comparison between the three tillage outfits and their possible cooperating tractors.

A point-by-point method was used in evaluation of the selected technical and exploitation parameters of tillage outfits and tractors. In the range from 1 to 5 points, the highest point value indicated the best evaluation of considered feature [Bedyk 2013].

The detailed results of own tillage outfits' evaluation are presented in Table 2, while the results of tractors' evaluation in Table 3.

The Unia Group tillage outfit obtained the highest score. In spite of highest price it was highly evaluated for its design and quality of work. It was also equipped with the leveling disk protection device that protected from stone damage. Wide adjustment possibilities and their simplicity are the advantages of this outfit; upon coupling to tractor the fuel consumption did not differ significantly from the implements of competitors.

The engine power of compared tractors was fitted to the analyzed outfits. The model New Holland T6.140 of maximal power 143 HP was the weakest tractor. Its engine meets the restrictive Tier 4A standards in respect of exhaust gas emission. In comparative analysis a special attention was paid to parameters that directly concerned the tractor utilization economy and the elements connected with comfort of work.

The Fendt and Case tractors have very similar parameters; they are modern and well equipped. The Case tractor is cheaper than Fendt, while the latter has lower fuel consumption. A decision towards tractor purchasing is undertaken for years. Since tractor is a work-place, the comfort and convenience of utilization are of some importance. One also expects the lowest tractor utilization costs; it is connected with the costs of

TABLE 2. Point evaluation of parameters and exploitation indices of analyzed tillage outfits

| Producer/parameters | Mandam (A1) | POM Brodnica (A2) | Unia Group (A3) |
|---|---|---|---|
| Price | 5 | 4 | 4 |
| Design | 3 | 4 | 5 |
| Coupling of outfit | 4 | 4 | 4 |
| Time of service | 4 | 3 | 3 |
| Working units (replacement costs) | 3 | 5 | 3 |
| Adjustments and room for them | 3 | 4 | 5 |
| Power requirement | 5 | 3 | 4 |
| Irregularity of cultivation depth | 5 | 3 | 5 |
| Coverage of crop residue | 4 | 4 | 5 |
| Protection of levelling section | 2 | 2 | 5 |
| Protection of working elements | 5 | 5 | 5 |
| Fuel consumption | 4 | 5 | 4 |
| Total points | 47 | 46 | 52 |

Source: own elaboration.

TABLE 3. Point evaluation of investigated tractors

| Producer/parameters | Fendt 516 Vario (C1) | New Holland T6.140 (C2) | Case IH Puma CVX 145 (C3) |
|---|---|---|---|
| Price | 3 | 5 | 4 |
| Price per 1 HP of engine power | 3 | 5 | 4 |
| Type of engine | 5 | 4 | 5 |
| Oil change interval | 4 | 4 | 5 |
| Specific fuel consumption | 5 | 4 | 3 |
| Transmission | 5 | 3 | 5 |
| Hydraulics and hydraulic lift | 5 | 4 | 5 |
| PTO | 5 | 4 | 5 |
| Ergonomics and cab comfort | 5 | 4 | 5 |
| Total points | 40 | 37 | 41 |

Source: own elaboration.

production agro-technique and determines the final profit of the farmer.

Basing on the summary results of point evaluation of particular tillage outfits and tractors there was developed a matrix of working outfits consisted of possible tillage outfit-tractor combinations (Table 4). In the matrix there were included number of points resulted from the sum of points for tillage outfits and tractors in particular combinations.

TABLE 4. Point matrix of tillage outfit-tractor sets

| Tractor (C)/Outfit (A) | A1 | A2 | A3 |
|---|---|---|---|
| C1 | 87 | 86 | 92 |
| C2 | 84 | 83 | 89 |
| C3 | 88 | 87 | 93 |

Source: own elaboration.

It is evident from Table 4 that the highest point value as obtained for the set of tillage outfit A3 with tractor C3 (the Unia Group outfit with Case tractor). The lowest point value was found for the set A2/C2 (the POM Brodnica outfit with New Holland tractor).

The developed point matrix was supplemented with the costs to be incurred, if the farm is equipped with every of possible combinations (tillage outfit + tractor). This comparison was presented also in the form of matrix (Table 5).

It is evident from data in Table 5 that the least costs are generated by the set of tractor C2 (New Holland) with any tillage outfit.

In the final part of comparative analysis there were determined the point values for particular sets (A/C). They are presented in the form of matrix, too (Table 6).

Analyzing the results of calculations of point values evaluation (Table 6) one can find that the least specific costs of investigated features of tillage outfit-tractor sets were obtained for the set of tractor C2 (New Holland) with tillage outfits. In the point matrix (Table 4) the sets with tractor C2 (New Holland) were characterized by lower number of points, however, the value of these points (Table 6) was lowest also; it determined the least specific costs of furnishing the farm with the working set including tractor C2 (New Holland). The proposed method of approach that involves evaluation of various tractor outfit combinations and their features can be used at the stage of technical equipment selection in the farms specialized in plant production.

TABLE 5. Cost matrix of tillage outfit-tractor sets [PLN]

| Tractor (C)/Outfit (A) | A1 | A2 | A3 |
|---|---|---|---|
| C1 | 384,820 | 390,300 | 390,800 |
| C2 | 267,820 | 273,300 | 273,800 |
| C3 | 323,320 | 328,800 | 329,300 |

Source: own elaboration.

TABLE 6. Matrix of point values evaluation for tillage outfit-tractor sets [PLN]

| Tractor (C)/Outfit (A) | A1 | A2 | A3 |
|---|---|---|---|
| C1 | 4,423 | 4,538 | 4,248 |
| C2 | 3,188 | 3,293 | 3,076 |
| C3 | 3,674 | 3,779 | 3,541 |

Source: own elaboration.

## CONCLUSION

As a result of implementation of modernized technology for winter triticale production that involves direct drilling, no financial advantages were found. Application of this technology resulted in the lower direct surplus value when compared to traditional cultivation system (with ploughing).

Application of direct drilling decreased the total costs of technical equipment exploitation, however, it did not compensated the lower incomes resulted from the reduced grain yield obtained.

Considering implementation of technologies that modernize the approach to soil cultivation and sowing of grain plants it is advisable to undertake not only the economic aspects, but also problems of work organization and protection of environment; they emphasize a critical evaluation of time-consuming and energy-consuming of traditional soil cultivation methods (including ploughing).

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**Streszczenie:** *Porównanie tradycyjnej i uproszczonej technologii produkcji zbóż z uwzględnieniem oceny sprzętu technicznego*. W pracy przedstawiono wyniki porównania technologii produkcji zbóż, zróżnicowanych pod względem podejścia do etapu uprawy gleby. Zakresem badań objęto czynniki kształtujące ekonomiczną efektywność produkcji zbóż przy wykorzystaniu technologii konwencjonalnej (z udziałem uprawy płużnej) i uproszczonej, z zastosowaniem siewu bezpośredniego. Na podstawie wyznaczonej nadwyżki bezpośredniej i innych wskaźników ekonomicznych przedstawiono różnice w efektach stosowania porównywanych systemów uprawy gleby. Przedstawiono wyniki oceny zestawień różnych ciągników z wybranymi agregatami uprawowymi.

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