JOHN DEERE COMBINE HARVESTERS FUEL CONSUMPTION AND OPERATION COSTS

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Abstract. This paper deals with comparison of the operating parameters of combine harvesters John Deere in a selected farm. The working parameters were measured on combine harvesters of the brand John Deere (tangential JD 2064, JD 9680 WTS, axialJD 9880 STS) of different ages and different concepts of threshing. Measuring took place in the season of 2012. Working parameters in this case mean the performance and economic indicators of the operation, i.e., the fuel consumption and costs. Performance of the machines was measured per hectare, number of harvested hectares per day, respectively per hour or season. Fuel consumption was measured in liters and converted per hectare and per kilometer travelled. Costs are calculated as fixed and variable and then summed as total for a given machine. They are also calculated per unit of one hectare. The measurement results are summarized in tables and charts and then elaborated in discussion.

Key words: combine harvester, harvesting, performance, fuel consumption, costs.

Introduction

Combine harvesters are an essential part of harvest of grain. That is why today they are very widespread in companies, in agricultural production companies as well as in service companies of agricultural machinery.

The emergence of a self-propelled combine harvester dates back to 1938 [1]. Since then the combine harvesters have undergone development of structural elements, which resulted in increasing throughput materials through combine harvesters. Figure 1 indicates the course in increasing of the throughput of combine harvesters from 1950 to the present [2].

The combine harvesters have also been divided according to different concepts of grain threshing and separation. Depending on the direction of the material throughput through the threshing mechanism the combine harvesters are divided into tangential (throughput along the tangent of the threshing drum) and axial (throughput in the direction of the axis of the threshing drum). Kumhála et al. [3] also state that English literature divides combine harvesters into "conventional" and "unconventional". By the conventional combine harvesters they mean all the classic technological conceptions, using the tangential way of threshing and keyboard straw walkers. By the conventional combine harvesters they mean all the other machines that use axial rotational elements for either separation of grain or grain threshing and separation.

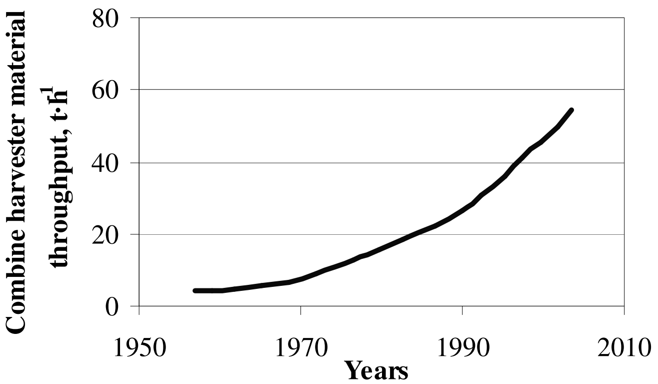

Fig. 1. **Increase of material throughput of combine harvester [2]**

The combine harvester is a seasonal machine which works only a few weeks or months in a year so buying a new combine harvester is a big investment. Such machines are required to provide the highest possible performance with the lowest possible operating costs. And the operating parameters of combine harvesters are discussed in this paper.

The working parameters were measured in the company of agricultural production on John Deere combine harvesters of different ages and of different conceptions of threshing, specifically tangential threshing concept JD 2064 (year of purchase 1996), JD 9680 WTS (year of purchase 2003) and axial threshing concept JD 9880 STS (year of purchase 2006). The measurements were carried out at harvests of cereals and oilseeds, specifically winter barley, spring barley, winter wheat, winter rape and with the machine JD 9880 STS also sunflower and corn.

The working parameters listed evaluated and discussed here are the measured fuel consumption, performance and costs of individual combine harvesters.

Materials and methods

Fuel consumption

Total daily fuel consumption (Q_{Total}) was measured every morning when refueling. The tank of the combine harvester was daily filled with diesel fuel by the fueling nozzle up to the fuel tank filler neck. Refueling fuel the volume of the fuel used was recoded. The total consumption was divided per harvested hectare (2) and per kilometer (1) travelled.

Consumption per kilometer was measured as follows.

- Filling up to the fuel tank filler neck.
- Travelling distance of the combine harvester coupled with:
  - cart with header (distance was deducted from;
  - tachometer of machines).
- Refilling to the fuel tank filler neck and recoding of volume.

$$Q_{km} = \frac{q_p}{s} \tag{1}$$

Q_{km} – fuel consumption per kilometre, l·km^{-1};
q_p – fuel consumed, l;
s– distance travelled, km.

The consumption per hectare has already been calculated from the total daily consumption, seeformula2. The daily harvested area was read from the board system GreenStar.

$$Q_{ha} = \frac{Q_{Total} - (Q_{km} * s_d)}{A_d} \tag{2}$$

Q_{ha} – fuel consumption per1 ha of harvested area, l·ha^{-1};
Q_{total} – total daily fuel consumption, l;
s_d – daily travelled distance, km;
A_d – daily harvested area, ha.

Performance

The data about the harvested area were read from the board system GreenStar after each harvested plot. The system can read the working width of the header in steps (or rows for row crops adapter), there by allowing to measure the harvested area precisely even in case of irregular plot (wedges, narrow lanes etc.).

Costs

Total cost (5) expended on the machine in 2012.

Fixed costs(3):

- depreciation;
- insurance;
- garage place;
- pre-seasonmaintenance;
- post-seasonmaintenance.

$$C_F = C_D + C_I + C_G + C_{PreM} + C_{PostM} \tag{3}$$

Variable costs(4):

- fuel costs;
- costs ofr epairs and servicing;
- labour costs for operators of the combine harvester.

$$C_V = C_{FC} + C_{RS} + C_{LO} \tag{4}$$

$$C_{Total} = C_F + C_V \tag{5}$$

The costs of maintenance, repair and service were read out of the company system.

The average humidity and average crop yields which are important for influencing the fuel consumption and performance were taken from the board system GreenStar.

Resultsand discussion

Fuel consumption

Consumption per 1 kilometer is on average 1,2 liters for all measured combines. For newer models JD 9680 WTS and JD 9880 STS the consumption is slightly lower. It is due to the fact that when you engage the third (road) gear the RPM are reduced to 1750 min^{-1}. JD 9880i STS had the highest total fuel consumption per travelling and the highest travelled distance during 2012. See Fig.2.

The total fuel consumption in 2012 was measured: JD 2064 3809 l, JD 9680 WTS, JD 9880i STS 147015 l.

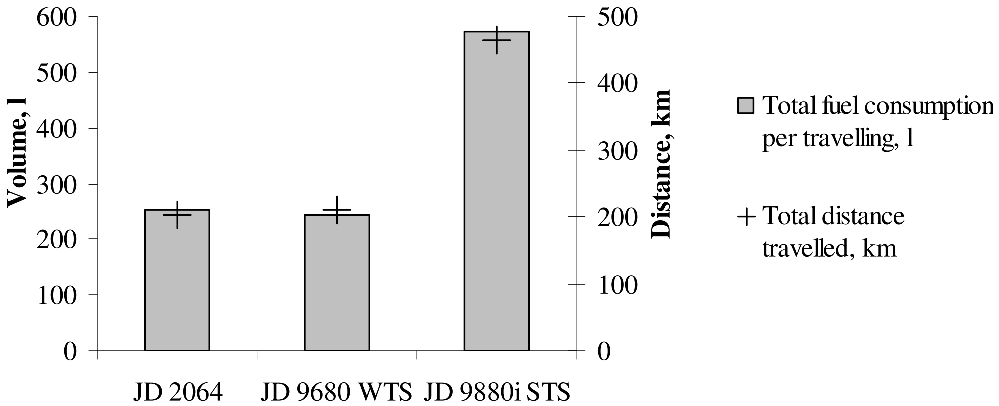

Fig. 2. **Fuel consumption per travelling**

Fig.3 shows a difference in consumption between tangential and axial ways of threshing. Specifically the tangentialmodelJD9680WTShason average 19 % lower consumption per 1 ha than the axial modelJD9880 STS. The JD2064isalso of tangential construction, but has 10 % higher consumption per 1 ha than the JD9880 STS. This is mainly due to the smaller working width.

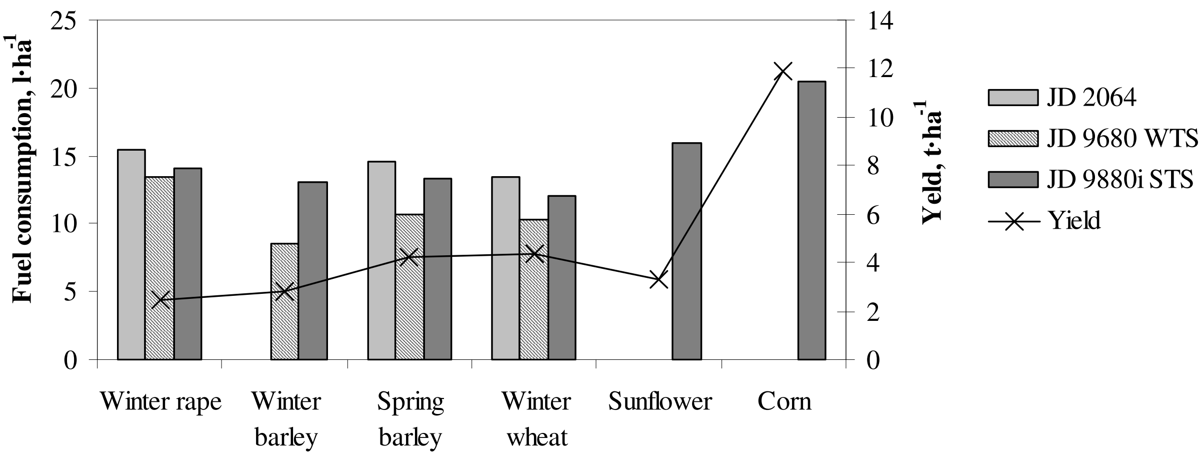

Fig. 3. **Fuel consumption per hectare**

Performance

Figure 4 shows the difference in performance between the tangential and the axial concept of combine harvesters. The axial machine JD 9880i STS was almost every time more efficient. Only when harvesting winter barley its performance was the same as for the combine harvester JD 9680 WTS. The reason for this was extra calibration of the machine at the beginning of the season. Because of the smaller work width and smaller grain tank the JD 2064 has the lowest hourly performance.

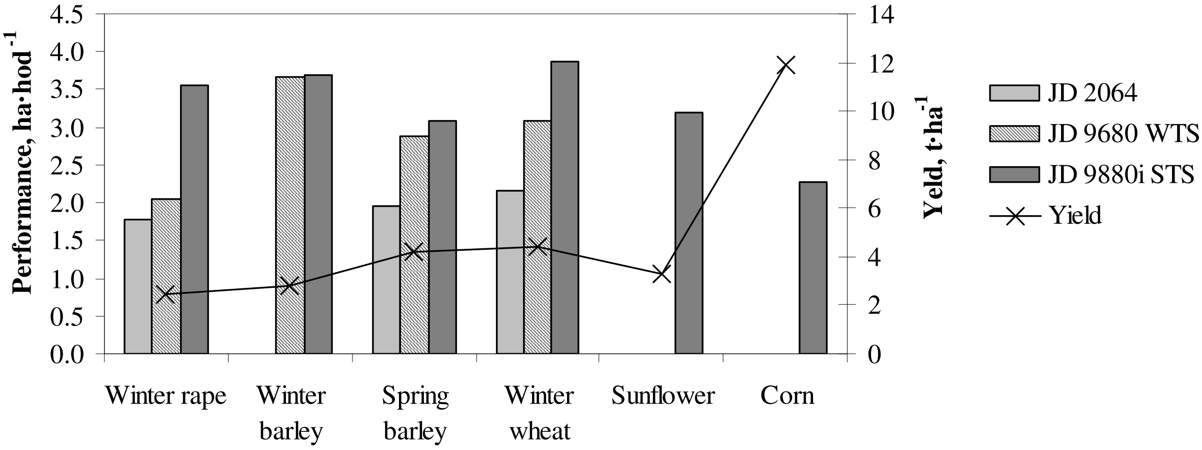

Fig. 4. **Performance per hectare**

In Figure 5 annual utilization of the measured combine harvesters in days and hours worked could be seen. The combine harvester JD 9880i STS is utilized a lot mainly due to the harvester of row crops (sunflower, corn). The harvester of these row crops by this combine harvester is also based on the axial concept. The axial concept was primarily intended for these crops. This annual utilization also translates into costs.

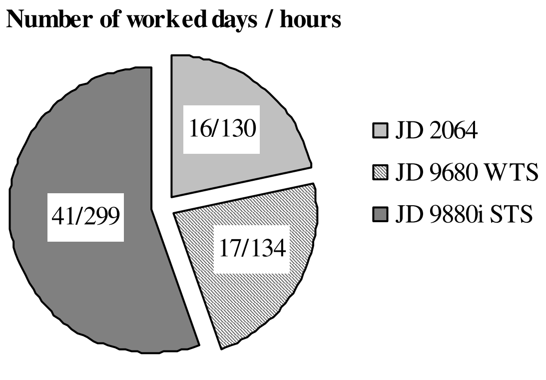

Fig. 5. **Annual utilization of combine harvesters**

Costs

The results of costs are particularly interesting, especially in terms of annual utilization of the machine. While the total costs of the machine JD 2064 came out the lowest, its costs of 1 harvested hectare are clearly the highest due to low annual utilization. The machine JD 9880i STS is exactly the opposite, the highest total costs, but the lowest costs per 1 harvested hectare. The optimal allocation of costs and annual utilization has been found with JD 9680 WTS. Given the age of the measured machines, the annual depreciation, which would significantly increase this item, already is not reflected anymore in costs.

Consumption and performance per area of the harvested crops in season 2012 compared to the other seasons is nonstandard because of atypical conditions of harvest. I.e., low yields of all crops, except for corn. Another factor affecting these parameters in the 2012 season was the yield of cereal straw. Most of the straw except rape straw was loosely deposited on the row for needs of livestock production and therefore the need for chopping the straw was minimal.

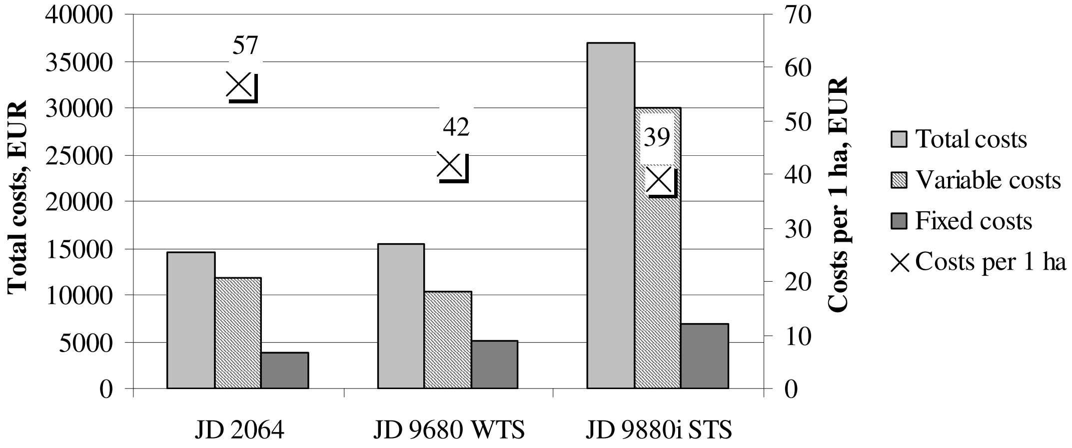

Fig. 6. **Costs per combine harvesters**

Conclusions

The measurements show that the measured parameters are dependent on the conditions of the season, especially on the condition of vegetation crops, i.e., yield of grain and straw.

The performance of combine harvesters depends on different age of the machine, different concepts of threshing and the separating mechanism and on appropriateness of using either concept to harvested crops. While the oldest tangential combine harvester JD 2064 had on average hourly performance of 1.94 $ha \cdot hod^{-1}$ the newer tangential combine harvester JD 9680 WTS had on average hourly performance of 2.76 $ha \cdot hod^{-1}$. Based on this the annual utilization and the total number of harvested hectares per season were derived. The axial combine harvester JD 9880i STS had the biggest hourly performance (3.18 $ha \cdot hod^{-1}$) as well as annual utilization, due to the harvest of sunflower and corn.

The performance is closely related to fuel consumption. Our research proved higher energy intensity of the axial concept of threshing and separation. Still the consumption per 1 hectare of the combine harvester JD 9880i STS was lower than the consumption of the combine harvester JD 2064, which is primarily due to a smaller working width. The combine harvester JD 9680 WTS proved to have the lowest consumption.

The JD 9880i STS had the highest total costs and the JD 2064 had the lowest total costs.

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