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EXPLOITATION ASSESSMENT OF NEW HOLLAND CX780 COMBINE HARVESTER

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ABSTRACT

The article presents an exploitation assessment of New Holland CX780 combine operation. Significant technical and technological progress is visible in modern harvesters. Inter alia, performance increased and elements improving the quality of work of harvesters appeared. The objective of the paper was to determine efficiency of the New Holland CX780 harvester operation including factors which affect its operation. Time structures of particular activities of combine operation and ratios of these times use were determined during tests. Yield value and moisture of collected seeds was determined. Studies proved that effective time of combine operation in the process of rapeseed and wheat grain harvesting was less than 50% and was caused by long preparation of a machine for operation. Preparation for operation of a combine influences its performance in the total time. It was 22% of the total operation time in case of wheat harvesting and 20% in case of rapeseed harvesting.

Introduction and objective of the paper

A high level of grain production is a factor which considerably influences the nutritional standard and economic development of the country. Combine models available on the market differ with exploitation and structural parameters. They also have a decisive impact on the work output (Wendel, 2004). Effectiveness of machines' operation depends greatly on the reduction of the number of faults which occur during their work. Producers successively introduce design changes in emergency components when analysing their frequency of occurrence. Currently, design changes of combine harvesters are reported mainly in harvesting and threshing components through the use of IT systems and equipping them with precise GPS. The most significant trend in the combines' progress is increase in their performance at the least possible work inputs and decrease of unit fuel consumption. To sum up, the structure of a machine must ensure great performance of its operation at the least possible financial inputs (Banasiak, 1999; Lorencowicz, 2008). Due to variability and great number of solutions, farm owners, before the purchase of a combine harvester, face the dilemma of choosing a specific machine type, which will absolutely meet their expectations. They are aware that obtaining a high performance of agricultural production is possible in case of correct selection of a machine to the farm size (Muzalewski, 2008). Therefore, one has to verify the usefulness of a device to the requirements used in a farm and applied technology of agricultural production. A correct quality of the harvested produce is related to carrying out all field works with the highest care possible, starting from soil cultivation ending with yield harvesting (Banasiak, 2004; Kuczewski and Majewski, 1999).

The objective of the paper was to determine performance of the New Holland CX780 harvester operation including factors which affect its operation. During research, time structures of particular activities of combine operation were determined, as well as work performance, time use ratios, yields and moisture of wheat and rapeseed grain.

Object and methodology of research

The investigated combine is included in the group of New Holland CX combines with a high technological structural advancement. Since there is no information on exploitation tests on this combine in the literature, an attempt to carry out such research was undertaken. It is equipped with a hydraulic drive system and a full system of electronic control of operation. It has the following systems: the system of maintaining the height of harvesting on a field with uneven surface, reversible drive of a reel, regulated location of the bottom part of a threshing floor. A harvesting unit with a working width of 5.18 m, diesel engine with a turbocharger of 207 kW power, sieves with the area of 5.40^2 and grain tank with 9 m^3 capacity were mounted in the combine harvester. A multi-drum threshing unit was used in the combine harvester. The tests were carried out on fields in Cerekwice, Katowice and Czachowice in Dolnośląskie Voivodeship. Rectangularly shaped fields were selected for investigations. Time structures of combine operation during the entire work time were selected for the research. Time studies were carried out on fields were wheat was sown (4 fields with the total surface area of 18.36 ha) and rapeseed (4 fields with the total area of 18.48 ha). The time was measured with a precision to 1 s, with the use of Olimpis Blueelite stopper. Moreover, yield and grain moisture were determined. During the harvest, meteorological conditions did not differ from the multiannual average. The studies were carried out according to the methodology accepted in the investigated combine harvesters (Molendowski, 2001; 2006; Molendowski et al., 2011; 2012; Molendowski and Siwiec, 2001; Mulka et al., 1996).

Tests results

Analysis of the tests results of the combine operation during rapeseed harvesting

Harvesting took place in the second decade of July 2014. The combine was working on fields sown with rapeseed with the surface area of: 4.24 ha, 4.87 ha, 5.19 ha. Four varieties of winter rapeseed were investigated: NKTechnic, Abacus, Xenon, Visby. Table 1 presents the size of acreage assigned to particular varieties and characteristics of the harvested crop of rapeseed varieties. Additional information consists of the effective time of combine's operation on a given field. The lowest rapeseed yield was on the field no. 4 (Visby variety) and it was 3.6 $Mg \cdot ha^{-1}$, and the highest was 4.3 $Mg \cdot ha^{-1}$ on the field no. 2 (NK Technic). Seeds moisture was within 9.1-9.4%. Effective time T_1 was from 98 min on the field no. 1 and on the field no. 4 it was 9 minutes higher. Average affective time T_1 was 101.8 min and in comparison to the total time T_{08} it was approx. 50% (tab.2). It means that the combine lost half of its time on other activities than yield harvesting. Time of returns T_{21} was more than 11 minutes, which constitutes 5% of the total time T_{08}; such result was related to the field length. An operator spent a lot of time for preparing a combine for operation T_{32}. It was as much as 42.6 minutes (20% of the total time) and for regulation T_{33} only 9.9 minutes. 9 minutes were spent to remove faults T_{41} and T_{42} which proves good condition of the combine. Rest time of the operator T_5 was 10 minutes.

Table 1.
Cultivation acreage and the acreage of the harvested yield of rapeseed varieties

Specification	Field no.			
	1	2	3	4
Field area (ha) Σ = 18.48 ha	4.24	4.87	4.19	5.19
Variety	NKTechnic	Abacus	Xenon	Visby
Yield (Mg·ha^{-1})	3.9	4.3	4.1	3.6
Moisture (%0	9.2	9.1	9.4	9.3
Effective time T_1 (min)	98	102	99	107

Table 2.
Time structure of particular activities during rape seeds harvesting (average values from 4 fields)

Item	Specification	Symbol	Time (min)
1	Effective time	T_1	101.82
2	Returns time	T_{21}	11.48
3	Idle crossings time	T_{22}	2.27
4	Technological stops time	T_{23}	6.32
5	Daily technical service time	T_{31}	3.02
6	Machine preparation time for operation	T_{32}	42.63
7	Regulations time	T_{33}	9.86
8	Technological faults removal time	T_{41}	5.52
9	Technical faults removal time	T_{42}	3.56
10	Rest time	T_5	9.61
11	Transport crossings time	T_{61}	5.86
12	Crossings time field to field	T_{62}	11.97
13	Daily technical service of commodity machines	T_7	0.00
14	Time losses due to organizational reasons	T_{81}	0.00
15	Time losses due to meteorological reasons	T_{82}	0.00
16	Total work time	T_{08}	213.91

The list of indexes and rates registered during rapeseed harvesting was presented in table 3. Operation efficiency W_{02} was 2.3 ha·h^{-1} and efficiency in the total time of change W_{08} 1.3 ha·h^{-1} and these were very low efficiencies. The working time use ratio K_{04} was 0.55 and of the exploitation time K_{07} 0.48, which means that only 55% of time was used for a direct rapeseed harvesting. The technological certitude ratio K_{41} and technical certitude ratio K_{42} and daily operation K_{31} were close to the unity which proves good quality of the combine and its operation. The average drive speed of the combine during harvesting was high and it was 7.6 km·h^{-1}. The effective time of combine's work was only 48% and the time of preparation of a machine for work was 20% of the total time of work during rapeseed harvesting. The time of other activities was within 1% to 6%.

Table 3.
Set of indexes and ratios of combine's work registered during rape seeds harvesting

Specification	Value
Effective performance W_1 (ha·h^{-1})	2.14
Operating performance W_{02} (ha·h^{-1})	2.27
Performance in the working time W_{04} (ha·h^{-1})	1.49
Exploitation performance W_{07} (ha·h^{-1})	1.30
Performance in the total time of change W_{08} (ha·h^{-1})	1.30
Operation time use ratio K_{02}	0.84
Working time use ratio K_{04}	0.55
Exploitation time use ratio K_{07}	0.48
Total time of change ratio K_8	0.48
Technological service ratio K_{23}	0.94
Technical operation ratio K_3	0.65
Daily service ratio K_{31}	0.97
Technological certitude ratio K_{41}	0.95
Technical certitude ratio K_{42}	0.97
Number of daily crossings on one field	41
Number of daily diagonal crossings	9
Number of daily crossings along the field	32
Number of daily returns on one field	37
Average speed of a combine along the field (km·h^{-1})	7.61
Time of the longest crossing along the field (minutes)	03:18
Time of the shortest crossing along the field (minutes)	01:27
The highest speed of the combine along the field (km·h^{-1})	9.57
The lowest speed of the combine along the field (km·h^{-1})	3.99

Analysis of the tests results of the combine operation during wheat harvesting

The combine was working on fields sown with rapeseed with the surface area of: 4.96 ha, 4.81 ha, 5.34 ha, 3.21 ha. Two winter grain varieties Boomer and Cubus were investigated. Table 4 presents the acreage of cultivation and characteristics of the harvested crop of wheat. Additionally, the last position includes the effective time of combine's work on the investigated fields.

Table 4.
Acreage of cultivation and characteristics of the harvested crop of the wheat grain

Specification	Field no.			
	1	2	3	4
Field area (ha) $\Sigma = 18.36$ ha	4.96	4.81	5.34	3.21
Variety	Boomer	Boomer	Cubus	Cubus
Yield ($Mg \cdot ha^{-1}$)	6.5	6.4	6.3	6.1
Moisture (%)	14.8	14.6	14.3	14.1
Effective time (min)	121	87	82	64

During the wheat harvesting, the highest yield was obtained on the field no. 1 (Boomer variety) and it was 6.5 $Mg \cdot ha^{-1}$ and the field no. 4 (Cubus) 6.1 $Mg \cdot ha^{-1}$. Moisture of the harvested wheat was from 14.1% to 14.8%. Effective time of combine's work on particular fields was from 64 minutes to 121 minutes which in relation to the total time was from 34% to 64.5% and depended on the field size. Table 5 presents average time structures for particular activities on the investigated fields during wheat harvesting.

Time of returns T_{21} was more than 10 minutes, which constituted 6% of the total time T_{08}, such result was related to the field length. An operator spent a lot of time for preparing a combine for operation T_{32}. It was as much as 38.3 minutes (20% of the total time) and for regulation T_{33} only 2.9 minutes. 7 minutes were devoted for removal of faults T_{42} and only ca. 3 minutes for the operator's rest T_5. The list of indexes and ratios registered during wheat grain harvesting was presented in table 6. Operation performance W_{02} was 2.5 $ha \cdot h^{-1}$ and efficiency in the total time of change W_{08} 1.56 $ha \cdot h^{-1}$ and these were low performances. The working time use ratio K_{04} was 0.54 and the exploitation time use ratio K_{07} 0.47. It means that only 54% of time was used for wheat grain harvesting and proves bad organization of combine operation. Technological certitude ratio K_{41} and technical one K_{42} and daily operation K_{31} were close to the unity which proves good quality of the combine and its operator. Average driving speed of the combine during harvesting was high and it was 7.62 $km \cdot h^{-1}$. The effective time of combine work was only 47% and the time preparation of a machine for work was 22% of the total time of work during wheat harvesting. The remaining times were within 1% to 9%.

Table 5.
Time structure of particular activities during wheat harvesting (average values from 4 fields)

Item	Specification	Symbol	Time (minutes)
1	Effective time	T_1	88.5
2	Time of returns	T_{21}	10.35
3	Time of idle crossings	T_{22}	4.84
4	Time of technological stoppages	T_{23}	11.67
5	Daily technical service time	T_{31}	1.8
6	Preparation for work time	T_{32}	38.32
7	Time of regulations	T_{33}	2.87
8	Technological faults removal time	T_{41}	0.00
9	Technical faults removal time	T_{42}	6.87
10	Rest time	T_5	2.73
11	Transport crossings time	T_{61}	3.14
12	Field to field crossings time	T_{62}	16.65
13	Time of daily technical service of commodity machines	T_7	0.00
14	Time losses due to organizational reasons	T_{81}	0.00
15	Time losses due to meteorological reasons	T_{82}	0.00
16	Total work time	T_{08}	187.74

Table 6.
The set of indexes and ratios of combine work registered during harvesting of wheat grains

Specification	Value
Effective performance W_1 (ha·h^{-1})	2.86
Operating performance W_{02} (ha·h^{-1})	2.52
Performance in the working time W_{04} (ha·h^{-1})	1.79
Exploitation performance W_{07} (ha·h^{-1})	1.56
Performance in the total time of change W_{08} (ha·h^{-1})	1.56
Operation time use ratio K_{02}	0.75
Working time use ratio K_{04}	0.54
Exploitation time use ratio K_{07}	0.47
Total time of change ratio K_8	0.47
Technological service ratio K_{23}	0.88
Technical operation ratio K_3	0.66

Specification	Value
Daily service ratio K_{31}	0.98
Technological certitude ratio K_{41}	1.00
Technical certitude ratio K_{42}	0.98
Number of daily crossings on one field	157
Number of daily diagonal crossings	36
Number of daily crossings along the field	121
Number of daily returns on one field	135
Average speed of the combine along the field, $(km \cdot h^{-1})$	7.62
The highest speed of the combine along the field, $(km \cdot h^{-1})$	10.61
The lowest speed of the combine along the field, $(km \cdot h^{-1})$	7.69

Figure 1 lists the time structure of particular activities of combine operation, which were determined during rapeseed and wheat harvesting. When comparing results of research on harvesting seeds of both plants one may notice that in case of rapeseed harvesting, effective time was longer by several minutes and it constituted 48% in the total work time and for wheat it was 47%. Return times were similar and the difference was 1% for the benefit of rapeseed harvesting. Idle crossings time indicates that in case of wheat grain harvesting more time was devoted to get to the trailer and field. It resulted from the fact that wheat yield was higher and the combine had to be unloaded more often and all unloadings took place on the parking. A similar situation concerns times of technological stoppages because the unloading time of tanks was similar in case of wheat and rapeseed. However, the number of unloadings of a tank was higher in case of wheat. Daily service time of a combine in both cases was the same and it was 1%. A difference may be reported in case of times of regulations which were carried out in combines. During rapeseed harvesting, there were more regulations (5%) because seeds harvesting required selection of the best parameters of work of particular combine units in order to achieve the best quality of harvested seeds. During rapeseed harvesting the rear part of a shaker was stuffed as a result of which combine was stopped for 22 minutes. Preparing a combine for work required a lot of time. It was as much as 20% in case of rapeseed harvesting and 22% in case of wheat. During harvesting of wheat grains the crossings time was 9% and it was related to the distance between fields. These distances were higher for wheat than for rapeseed. Generally, one may state that there are no considerable differences between the times of particular activities during wheat and rapeseed harvesting.

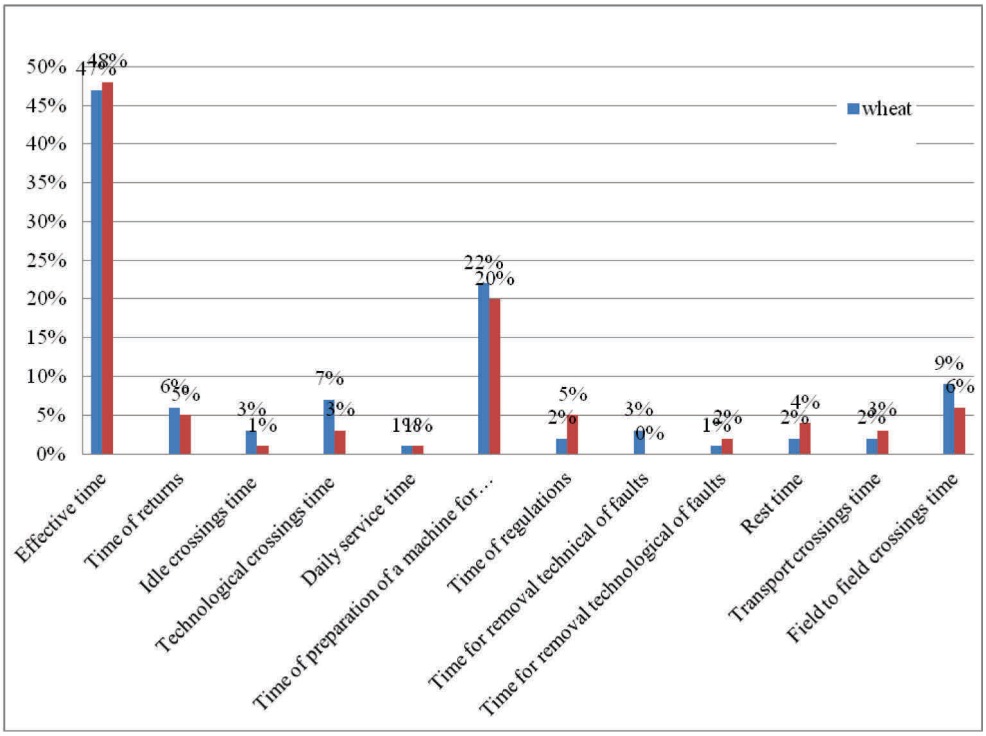

Figure 1. Time structure for particular activities during wheat and rapeseed harvesting

Conclusions

1. Effective time of NH- CX780 combine work was less than 50% of the total work time of rapeseed and wheat grain harvesting was related to preparing a machine for work and crossings time between the fields.
2. Moisture of harvested seeds was within 9.1 to 9.4% for rapeseed and 14.1 to 14.8% for wheat.
3. Distance between the fields influenced effective performance of a combine. For crossings during wheat harvesting this time was 9% and for rapeseed it was 6% of the total time of machine operation.
4. Preparation for operation of a combine influenced the performance of a combine in total time. It was 22% of the total operation time in case of wheat grain harvesting and 20% in case of rapeseed harvesting.

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OCENA EKSPLOATACYJNA KOMBAJNU NEWHOLLAND CX780

Streszczenie. W artykule przedstawiono ocenę eksploatacyjną pracy kombajnu New Holland CX7080. W nowoczesnych maszynach do zbioru zbóż nastąpił istotny postęp techniczny i technologiczny, między innymi wzrosła wydajność, a w wyposażeniu pojawiły się elementy poprawiając ich jakość pracy. Celem badań było określenie wydajności pracy kombajnu zbożowego firmy New Holland CX780 z uwzględnieniem czynników mających wpływ na jego pracę. Podczas badań wyznaczono struktury czasu poszczególnych czynności pracy kombajnu i współczynniki wykorzystania tych czasów. Określono także wartość plonów oraz wilgotność zbieranych nasion. Badania dowiodły, że efektywny czas pracy kombajnu w procesie zbioru nasion rzepaku i ziarna pszenicy wynosił niecałe 50% i spowodowany był długim czasem przygotowania maszyny do pracy. Wpływ na wydajność kombajnu w czasie ogólnym zmiany ma jego przygotowanie do pracy i wynosiło ono 22% całkowitego czasu pracy w przypadku zbioru pszenicy i 20% w przypadku zbioru rzepaku.

Słowa kluczowe: kombajn zbożowy, eksploatacja, zbiór, pszenica, rzepak