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Comparative analysis of agricultural tractors functional features determining their selection for the farm

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Abstract: *Comparative analysis of agricultural tractors functional features determining their selection for the farm.* The work aimed at comparison of selected functional features for the three tractors that might be considered in the farm performing the machine fleet modernization. The comparative analysis, including statistical analysis, was carried out on the basis of survey investigations with consideration to various categories of tractor parameters and functional features assessed by the questioned persons.

Key words: survey, tractor, selection, comfort, three-point suspension system, fuel consumption.

INTRODUCTION

Undertaking decision on providing the farm with a new or second hand agricultural tractor is regarded as especially responsible task, since possible errors made in the stage of tractor purchase preparation and selection affect the later evaluation of the tractor's functional features and economic indices, including maintenance and exploitation cost of vehicle [Pawlak 2001].

Variety of tractors on the market is undoubtedly a factor that promotes the precise matching of vehicle to the farm's needs [Lorencowicz 2007]. However, the large number of features to be considered in tractor assessment calls for complex approach to such composite task as selection of energy source for agricultural machines and implements [Gaworski 2010].

In the context of wide problems of tractor selection it is important to search for the plane of opinions that promote undertaking the decisions on providing the farm with properly matched agricultural tractors.

The work aimed at comparison of selected functional features for the three tractors that might be considered in the farm performing the machine fleet modernization.

METHODOLOGICAL ASPECTS OF ANALYSIS

In realization of the work's aim there was assumed the adequate methodology procedure involving the survey among the agricultural producers' group that owned the tractors of makes being compared. In selection of questioned persons a criterion of their acquaintance with utilization of at least two out of three investigated tractors, namely: John Deere, MTZ and Zetor. Besides, the questioned group of agricultural producers was selected in order to collect the same number of questionnaires connected to each tractor being compared. Out of 60-person group, for detailed analysis there was

taken 10 assessments for each tractor; the questionnaires incomplete or improperly filled in were rejected.

The survey questions were divided into several categories to assess: tractor engine and its power, power train system, power take off devices, hydraulics, cab and its equipment, service range and ease, failure frequency and others. The questioned persons answered using the 0 to 5 scale. The obtained scores were summed up for particular tractor makes and data categories. These sums were used in statistical analysis.

To evaluate the effect of tractor make on particular parameters' assessment, the results were statistically analyzed with the one-factor random block sampling method.

This method is used when heterogeneity of experimental units results from the occurrence of one-way systematic variability of a given feature assessment. It enables to eliminate heterogeneity effects on the investigated feature and involves grouping of experimental units into blocks to obtain the systematic differentiation of conditions between them, while the random variation of conditions within the blocks.

To investigate the effect of tractor make and parameters on final assessment of particular tractors with the use of variance analysis method and *Statgraphics* program, the following hypotheses were made:

- H_{OB}: the make does not affect significantly the final assessment,
- H_{OC}: the parameters do not affect significantly the final assessment,
- H_{OBC}: there is no interaction between make and parameters.

According to analysis of variance, hypotheses H_{OB} and H_{OC} should be rejected, if p-value is < 0.05 which means that the make and parameters affect significantly the final assessment. Hypothesis H_{OBC} should be rejected also, if p-value is < 0.05, which proves the occurrence of interaction between the make and parameters considered.

RESULTS OF ANALYSIS

According to analysis of variance, hypotheses H_{OB} should be rejected, since p-value is < 0.05 which means that the make affects significantly the engine power assessment. The results of engine power analysis of considered tractors are presented in Figure 1.

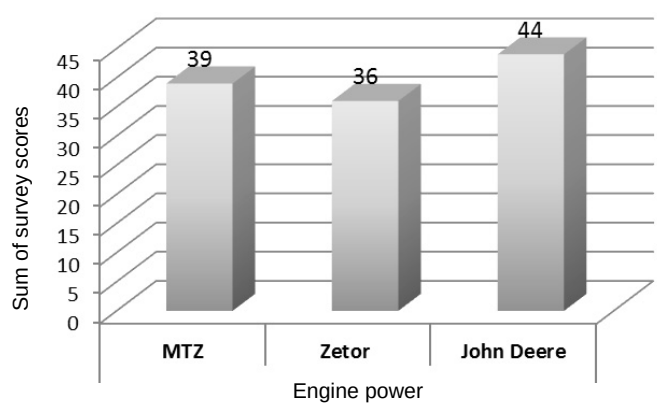

FIGURE 1. Results of engine power analysis of investigated tractors

One can read off from the differences in mean squares that the best assessments of engine power were found for John Deere tractor; they differed significantly from other tractors' assessments. The highest significant difference was found between John Deere and Zetor tractors.

According to analysis of variance, there is no ground for rejection of hypothesis H_{OB}, since p-value is > 0.05 which means that the make does not affect significantly the fuel consumption assessment.

The results of investigations on fuel consumption are presented in Figure 2.

One can read off from the differences in mean squares that the best assessments of fuel consumption were found for MTZ tractor; they differed significantly from other tractors' assessments. The highest significant difference was found between MTZ and John Deere tractors.

According to analysis of variance, hypotheses H_{OC} should be rejected, since p-value is < 0.05 which means that the make affects significantly the assessments of lift capacity and operational effectiveness of three-point suspension system. The results of lift capacity analysis of considered tractors are presented in Figure 3.

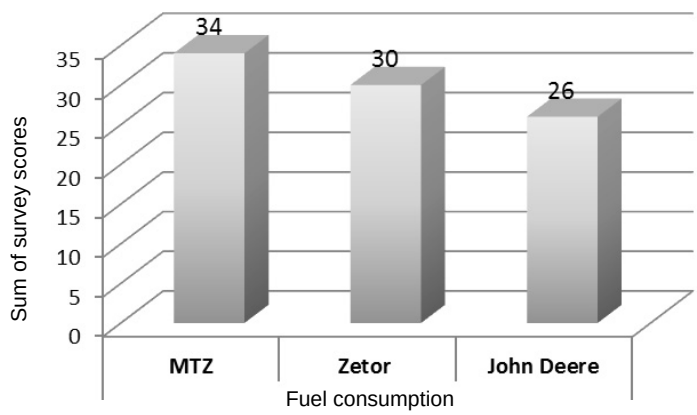

FIGURE 2. Results of investigations on fuel consumption of investigated tractors

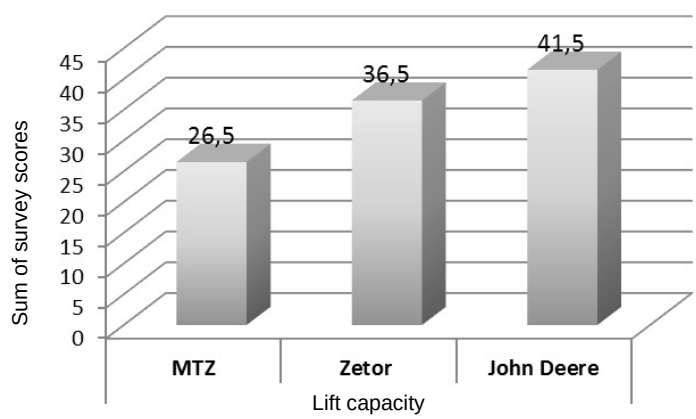

FIGURE 3. Results of investigations on lift capacity of investigated tractors

One can read off from the differences in mean squares that the best assessments of lift capacity and operational effectiveness were found for John Deere tractor. The highest significant difference was found between John Deere and MTZ tractors.

According to analysis of variance, hypotheses H_{OB} should be rejected, since p-value is < 0.05 which means that the make affects significantly the comfort and esthetic appearance assessment. The results of operational comfort analysis of considered tractors are presented in Figure 4.

One can read off from the differences in mean squares that the best assessments of operational comfort and esthetic appearance were found for John Deere tractor. The highest significant difference was found between John Deere and MTZ tractors.

According to analysis of variance, hypotheses H_{OC} should be rejected, since p-value is < 0.05 which means that the make affects significantly the draft assessment. The results of draft analysis of considered tractors are presented in Figure 5.

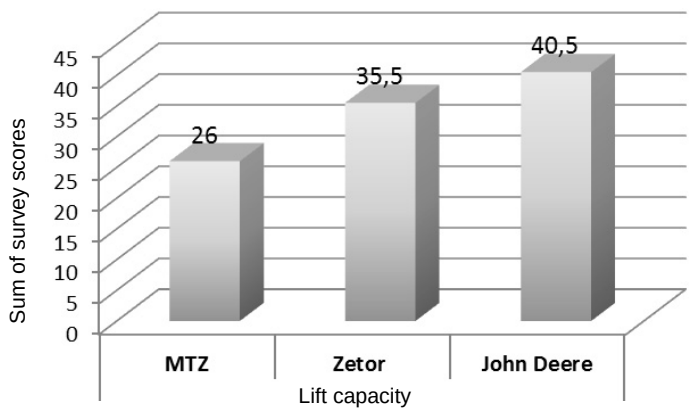

FIGURE 4. Results of investigations on operational comfort of investigated tractors

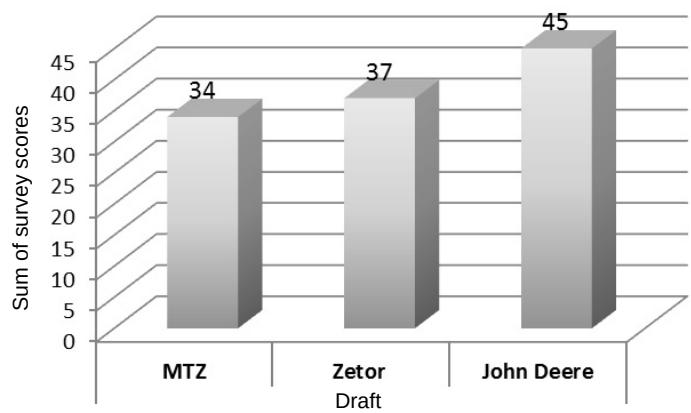

FIGURE 5. Results of investigations on draft of investigated tractors

One can read off from the differences in mean squares that the best assessments of draft were found for John Deere tractor. The highest significant difference was found between John Deere and MTZ tractors.

According to analysis of variance, there is no ground for rejection of hypothesis H_{OB}, since p-value is > 0.05 which means that the make does not affect significantly the daily service assessment.

The results of investigations on daily service are presented in Figure 6.

One can read off from the differences in mean squares that the best assessments of daily service were found for John Deere tractor; they differed significantly from other tractors' assessments.

Comparing the effects of make and parameters one can find that the final assessment was affected by tractors' utility features in 67.29%. However, this was significant that over 30% of assessments were suggested by the make.

The square sum test showed that the best assessment was found for John Deere tractor, however, the scores differed significantly. The tractor MTZ got the worst scores (Fig. 7).

Considering the number of highest scores one can find that a leading place in the ranking is taken by John Deere. This tractor got 18% of the highest scores (55% of all scores for this tractor).

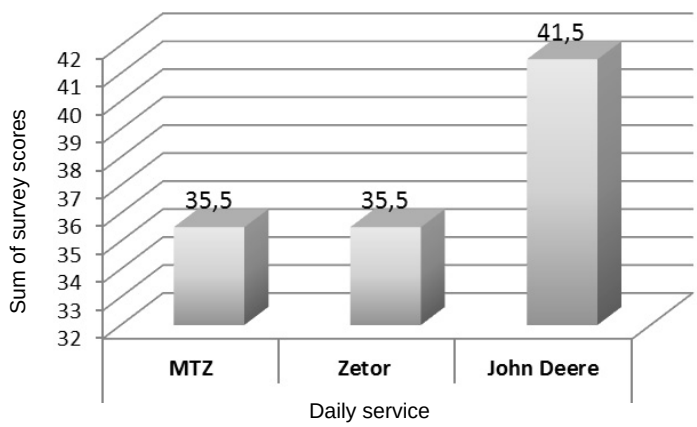

FIGURE 6. Results of investigations on daily service of investigated tractors

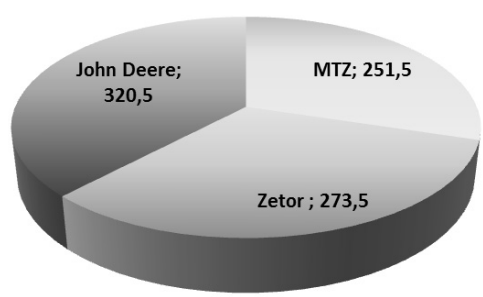

FIGURE 7. Comparison of tractor make and parameters effects based on score sums obtained in survey

RESULTS DISCUSSION AND SUMMARY

The initial analysis of variance illustrated the effect of tractor make and parameters tested on final assessment of tractors.

Comparing the effects of make and parameters one can find that the final assessment was affected by tractors' utility features in 67.29%. However, this was significant that over 30% of assessments were suggested by the make. Therefore, the question arises: what scores would have been achieved by tractors if they had been tested anonymously? One can suspect that the 55%-result obtained by John Deere tractor was influenced to some extent by the make prestige. The detailed variance analysis of assessment for particular parameters in respect to the make showed, that in the case of fuel consumption and daily service, one could find no make effect on the assessment.

The Pearson's correlation analysis revealed the dependence between scores of some parameters, e.g. the operational comfort was highly correlated with lift capacity and performance effectiveness of three-point suspension system, as well as with hydraulic system output.

As results from carried out analysis, John Deere tractor predominates among other tractors compared. The only weak point of this tractor, indicated by the questioned persons, was fuel consumption; MTZ tractor was best in this respect.

The best engine power was pointed out for John Deere, followed by MTZ and Zetor. It is partially connected with transmission design; John Deere and MTZ tractors have far more gear speeds than Zetor and the improved flexibility of engine power utilization.

John Deere tractors were equipped with hydrostatic and hydrokinetic drive transmissions controlled hydraulically to provide smoothness of half gear shifting under load. The users of these tractors often complained of too sensitive gear shift lever; apart from that, transmissions used in these tractors were described in superlatives. In the case of Zetor tractor they complained of jerking during half gear shifting. It results from aggressive operation of pneumatic system used by operator to control half gears. This disadvantage places Zetor transmission operation below John Deere performance.

Survey data of tractor draft classify the tractors in the sequence according to their mass: the best John Deere, then Zetor and MTZ.

Among tractors being compared, the easiest daily service was found for John Deere tractor. Zetor and MTZ obtained the same score, however, the Zetor users complained of hood opening mechanism design, which should be daily disassembled (it has been repaired in newer models).

In the case of three-point suspension system and hydraulics service, the highest scores were found for John Deere again, while the lowest scores for MTZ; in spite of passing time, it has been still produced according to design of the eighties.

The comfort level sequence from the best to the worst tractor is as follows: John Deere, Zetor, MTZ. The MTZ design was slightly changed, therefore, no great comfort improvement could be expected. John Deere and Zetor aim at continuous improvement of technical solutions used in the currently produced models; this greatly enhances a systematic improvement of operational com-

fort of tractors subjected to investigations [Chojnacki 2011]. It is connected in great part with dynamic implementation of electronics to contemporary tractors [Gaworski 2011].

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Streszczenie: *Porównawcza analiza funkcjonalnych cech ciągników rolniczych, kształtujących ich dobór do gospodarstwa.* Celem pracy było porównanie wybranych cech funkcjonalnych trzech ciągników, które mogłyby znaleźć się w wyposażeniu gospodarstwa rolnego podejmującego modernizację parku maszynowego. Porównawczą analizę, w tym analizę statystyczną, przeprowadzono na podstawie badań ankietowych, w których uwzględniono różne kategorie parametrów i cech funkcjonalnych ciągników ocenianych przez respondentów.

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