

## DETERMINATION OF AGRICULTURAL MACHINERY OPERATORS' OPINIONS ABOUT THE CABIN COMFORT IN ESKİŞEHİR

Özge ACARBAŞ BALTACI<sup>1\*</sup>, Savaş YAPICI<sup>1</sup>, Ömer Faruk EROL<sup>1</sup>, Zeki YILDIZ<sup>2</sup>

<sup>1</sup>Hisarlar Makine A.Ş., Eskişehir, Turkey

<sup>2</sup>Department of Statistics, Faculty of Science and Art, University of Eskişehir Osmangazi, Eskişehir, Turkey

\*Corresponding author: e-mail: [ozgeacarbasbaltaci@hisarlar.com.tr](mailto:ozgeacarbasbaltaci@hisarlar.com.tr)

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**Abstract:** Comfort has a great importance in the interior design of tractor and agricultural machinery cabins. Operators are exposed to musculoskeletal system disorders since they spend long time periods during the day in these vehicles. There is a few work in the literature reporting operators' opinions about cabin comfort of these machineries. In this study, a questionnaire was conducted in order to get information about agricultural machinery operators' opinions about the comfort of their vehicles. Tractor cabins and combine harvester machine cabins were selected as machineries. The study was conducted in Eskişehir in Turkey. Questionnaire was composed of four groups of questions and five ordered response levels were used in the Likert's scale. Demographic questions, general questions about the machine, personal evaluation questions and open ended questions were asked to the operators. After the questionnaire completed, collected data were classified according to the machine type. Frequency tables were used to present the results. Visibility and the accessibility were the most satisfied issues for the tractor operators with 55.9% and 55.4% percentages, respectively. Seat comfort has the highest satisfaction degree with 43.7% for the combine harvester operators. Cronbach Alpha reliability coefficient was used for the satisfaction questions in the applied questionnaire. The reliability of the study was high with coefficients of 0.878 and 0.940 for the tractor and combine harvester questionnaires, respectively. This study will support design and development process of new products by considering operator opinions.

**Key words:** Cabin interior design, cabin comfort, tractor cabin, combine harvester cabin

### Eskişehir'deki Tarım Makinesi Operatörlerinin Kabin Konforu Hakkındaki Düşüncelerinin Belirlenmesi

**Özet:** Traktör ve iş makinesi kabin içi tasarımında konfor büyük öneme sahiptir. Operatörlerin çoğu bir gün içinde uzun süreler boyunca söz konusu araçları kullandıkları için kas ve iskelet sistemi rahatsızlıklarına maruz kalmaktadırlar. Literatürde bu konuda operatörlerin fikirlerine yer veren çalışmalara az rastlanmaktadır. Bu nedenle bu çalışmada daha konforlu bir araç içi tasarımı ulaşılabilmek için geliştirilmesi gereken konular üzerine operatörlerin fikirlerini almak için bir anket çalışması yürütülmüştür. Söz konusu anket çalışmasına konu olarak Türkiye'de yaygın olarak kullanılan traktör kabini ve biçerdöver kabini seçilmiştir. Çalışma Eskişehir/Türkiye'de yürütülmüştür. Operatörlere uygulanan ankette dört grup soru yer almaktadır ve ankette 5'li Likert ölçeği kullanılmaktadır. Operatörlere demografik sorular, makineyle ilgili genel sorular, kişisel değerlendirme soruları ve açık uçlu sorular sorulmuştur. Anket tamamlandıktan sonra toplanan veriler makine tipine göre sınıflandırılmıştır. Derlenen sonuçlar frekans tablolarıyla sunulmuştur. Görünürlük ve erişilebilirlik traktör operatörlerine göre sırasıyla %55.9 ve %55.4 oranlarıyla en çok memnuniyet duyulan konulardandır. Biçerdöver operatörleri için de oturma bölgesi konforu %43.7 oranıyla en çok memnun olunan konudur. Bu çalışmada memnuniyet soruları için Cronbach Alpha güvenilirlik katsayısı kullanılmıştır. Çalışmanın güvenilirliği traktör anketi için 0,878, biçerdöver anketi için 0,940 katsayılarıyla yüksektir. Bu çalışma operatörlerin fikirlerini dahil ederek yeni ürün tasarım ve geliştirme sürecini destekleyecektir.

**Anahtar kelimeler:** Kabin içi tasarım, kabin konforu, traktör kabini, biçerdöver kabini

### Introduction

Tractor and agricultural machinery operators spend long time periods in their vehicles during the day and they are exposed to musculoskeletal system disorders. Operators sometimes alter their posture to use the machine in an easier way and increase their postural strains (Barron et al. 2005). During the operation in the agricultural machinery, improper cabin design and work procedures bring these musculoskeletal disorders

(Kittusamy 2003). Because of this fact, comfort plays an important role in the vehicle design (Kuijt-Evers et al. 2003). Cabin design has a particular importance since operators operate their vehicles in the cabins. Yadav and Tewari (1998) stated that if tractor cabins are designed in a suitable manner, comfort will be increased accordingly and thus efficiency of the agricultural works will be improved.

In a survey conducted related to the comfort of the tractors, most of the operators mentioned the difficulty of reaching the driving seat and most of the operators had medical complaints (Gibbon 1970). In the vehicle cabin, design should permit the operator to reach all controls easily, so that operator effort and stress might be minimized (Yadav and Tewari 1998). Well-designed cabins reduce these complaints and improve the operator performance. In high income countries most of the agricultural machinery have cabins but this is not the case in low income countries due to economic reasons (Patel et al. 2000).

During the design period opinion of the operators is important to reach a success, since they are the end users of the machines. Most of the consumer foresights have an influence over the product development. They could foresee the future, so their responses play a part in the innovations in the market (Samli 2011). People generally interact with the product that they use, they perceive the product with their senses (Hekkert and Schifferstein 2007). Therefore, users opinion is one of the most important criterion in the design process.

The aim of this study is to incorporate the opinions of the tractor and combine harvester machine operators into the cabin design period to reach comfortable conditions.

### Materials and Methods

In this study a questionnaire was conducted in order to get information about agricultural machinery operators' opinions about the comfort of their vehicles. Tractor cabins and combine harvester machine cabins were selected. The tractor questionnaire study was conducted in Eskişehir's central districts and villages through the face to face interview method. In this region, tractors with a horse power higher than 36 hp are mostly used and the number of such tractors is 2222. Combine harvester questionnaire study was conducted both in central and other districts and villages and there are total 850 combine harvesters (TUIK 2013 data). 121 tractor operators and 36 combine harvester machine operators, representing approximately 5% and 4% of the total numbers, respectively, were included in the study. Although the study was conducted among the machineries with cabins, most of the tractors and combine harvesters have no cabins. So, these percentages were indeed more higher than the given values and they can be considered as representative values.

Questionnaire was composed of four groups of questions. First group contained demographic questions about the operators including their gender,

age, weight and length, years of experience etc. The second group questions were general questions about the machine, like year and model of the machine, engine volume and whether or not the machine is second hand or new. The third group included personal evaluation questions about the machines. Five ordered response levels were used in the Likert's scale for this part. In the last group, supplementary open ended questions were asked to the operators. After the questionnaire completed, collected data were classified according to machine type. Frequency tables were used to present the results. Opinions about general machine comfort and comfort related to specific parts of the machinery were given in the frequency tables. Also, in order to analyse the data collected through the questionnaire cross charts, correlation analysis and reliability analysis were used.

### Results and Discussion

Table 1 and Table 2 show the descriptive statistics about the personal variables of tractor operators and combine harvester operators, respectively. These personal information would be related with the questionnaire results, but since there was no meaningful correlation between the personal variables and results of the questionnaire, these variables were not used. The only correlation was found between the operators' age and general satisfaction degree.

Spearman raw correlation coefficient was used to find the correlation between the operators' age and general satisfaction degree. Results were given in Table 3. There is a weak direct relation with the operators' age and satisfaction degree ( $r=0.074$ ) for the tractor study, but this relation is not statistically significant. For the combine harvester study this coefficient is -0.420 and this means there is a medium degree negative relation between the combine harvester operators' age and general satisfaction.

Fig. 1 and Fig. 2 show the general opinion about comfort of the cabins. The answers given to the related questions gave us the preliminary information about operator's thoughts about comfort. Answers were classified and evaluated in order to use the operator's opinion on design and development processes.

According to Fig. 3, it can be concluded that the storage space has the lowest satisfaction degree for the tractor operators, 44.6% of operators rated storage space as "bad". On the other hand visibility and accessibility issues have higher satisfaction degrees. 55.9% and 55.4% of operators rated visibility and accessibility as "good", respectively.

**Table 1.** Descriptive statistics related with the personal variables (Tractor operators)

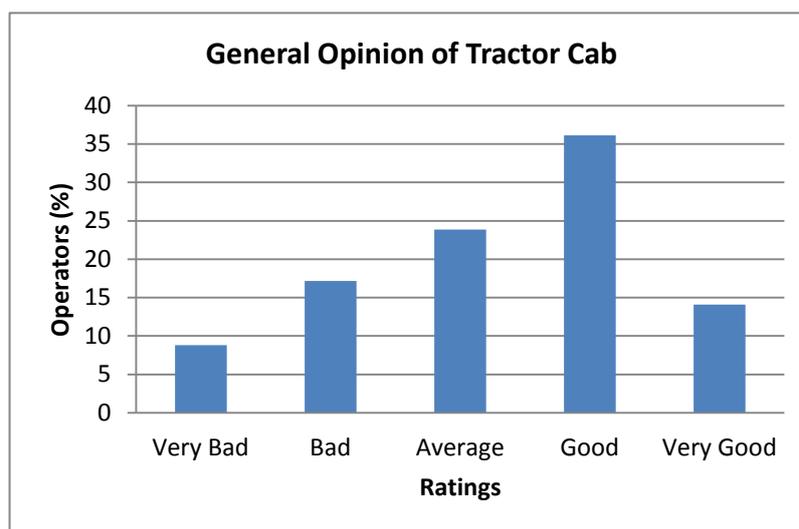
	N	Minimum	Maximum	Mean	Std. Deviation
Age	119	19,00	68,00	48,8487	11,20203
Weight	116	49,00	120,00	81,1810	13,81278
Length	116	1,60	1,85	1,7294	0,05925
Operation Time	116	0,50	20,00	6,8621	3,93843
Experience	120	4,00	60,00	29,6917	11,47800
Motor Power	115	48,00	100,00	76,1739	12,69774
Valid N (listwise)	107				

**Table 2.** Descriptive statistics related with the personal variables (Combine harvester operators)

	N	Minimum	Maximum	Mean	Std. Deviation
Age	35	22,00	67,00	47,4000	13,71817
Weight	33	72,00	120,00	91,9091	12,36013
Length	33	1,64	1,90	1,7573	0,06115
Operation Time	35	8,00	24,00	13,0571	4,12270
Experience	36	2,00	50,00	24,5556	12,00820
Motor Power	33	105,00	250,00	164,0606	49,62480
Vehicle Age	36	1,00	38,00	20,3889	13,24554
Valid N (listwise)	29				

**Table 3.** Correlation results between operator age and general satisfaction

			Age	Satisfaction
Tractor	Spearman's rho AGE	Correlation Coefficient	1,000	0,074
		Sig. (2-tailed)	.	0,423
		N	119	119
Combine Harvester	Spearman's rho AGE	Correlation Coefficient	1,000	-0,420
		Sig. (2-tailed)	.	0,012
		N	35	35



**Fig. 1.** General opinion about comfort of the tractor cabins

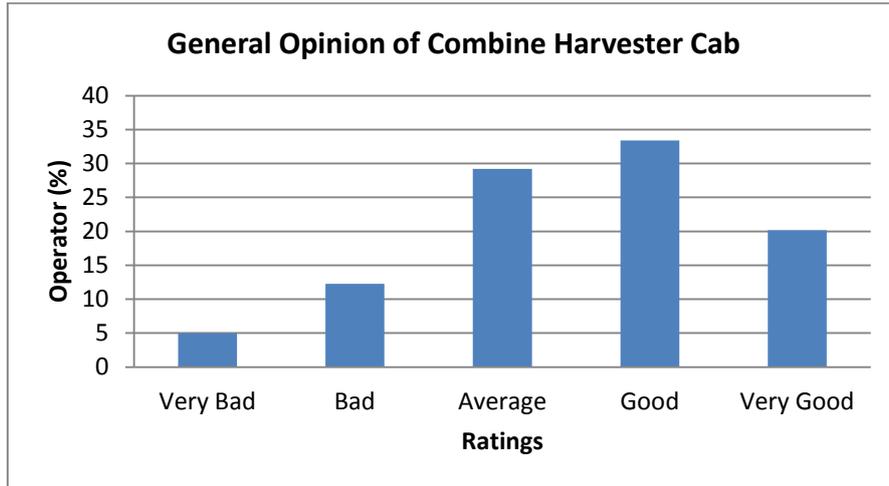


Fig. 2. General opinion about comfort of the combine harvester cabins

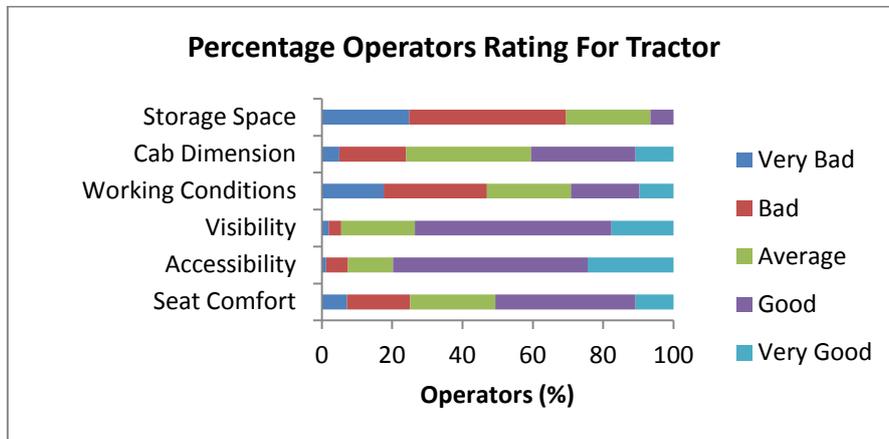


Fig. 3. Opinion of tractor operators about specific parts of the machines

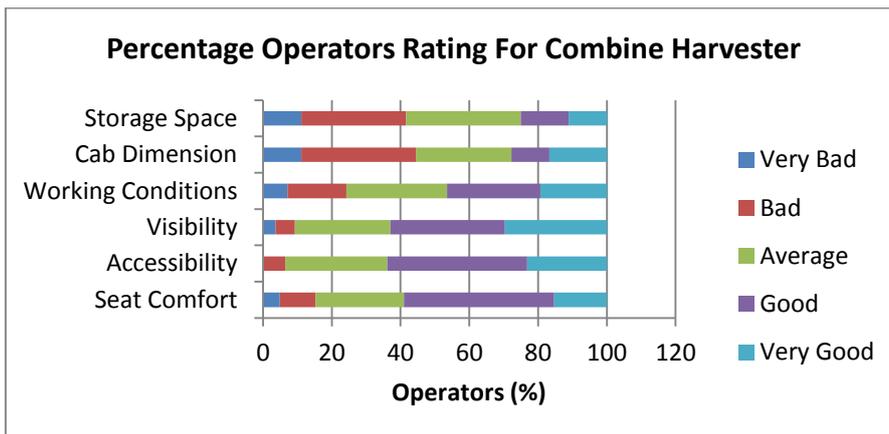


Fig. 4. Opinion of combine harvester operators about specific parts of the machines

For the combine harvester operators cabin dimension and storage space have the lowest satisfaction degrees with 33.3% and 30.5%, respectively. Seat comfort has the highest satisfaction degree with 43.7% (Fig. 4).

Examples given in Table 4 and Table 5 were the aspects that were mentioned by the operators during the questionnaire. These aspects were classified into 6 categories for tractors (Table 4) and 5 categories for combine harvesters (Table 5) (Kuijt-Evers et al. 2003).

The classification was made according to important factors for the design process. Main categories are the design criterion and categorized in a logical manner. Factors like working area in the cabin and distances between the equipments and operator were classified in the “dimension” category. Ease of handling of the equipments, their simplicity and understandability were classified in the “usefulness” category. Since criteria related with the seat can affect the seating comfort of the operator, they were classified in the “seat comfort”

category. Criteria related with the operators visibility of the machine's front, sides and rear and the visibility of the indicators on the dashboard were put in the “visibility” category. Factors that affect the life quality during the usage of the machine were classified in the “working condition” category. Factors that affect the failure period and that are related with the materials were classified in the “material quality” category.

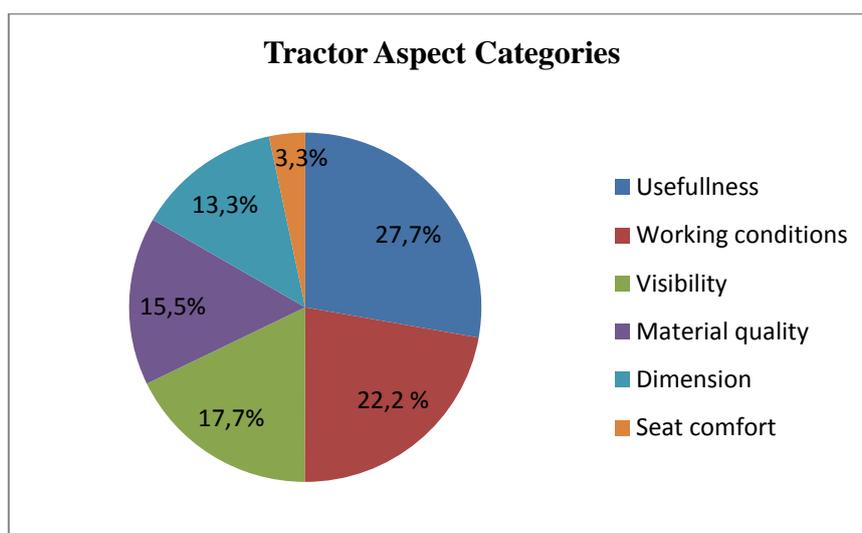
Figs. 5 and 6 show the percentages of these aspects for tractor and combine harvester.

**Table 4.** Classification of aspects mentioned by operators for tractors

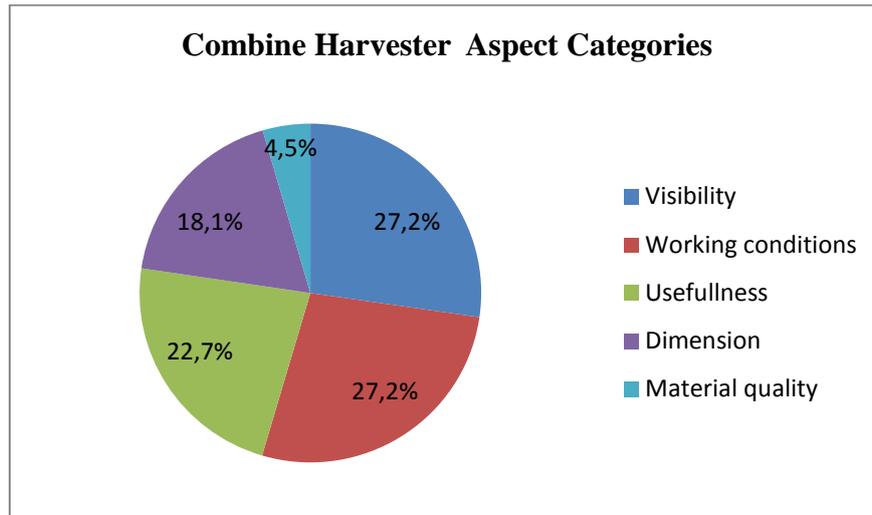
Categories	Examples
<b>Dimension</b>	Extra seat, cabin dimension
<b>Usefulness</b>	Refrigerator, storage space, door, steps, steering wheel, accelerator and clutch pedals
<b>Seat comfort</b>	Lumbar support, back support
<b>Visibility</b>	Mirrors, front-side-rear windows, lighting
<b>Working conditions</b>	Air conditioner, dusting, noise
<b>Material quality</b>	Door plungers, windscreen wiper, lamps, gaskets, boot rubbers

**Table 5.** Classification of aspects mentioned by operators for combine harvesters

Categories	Examples
<b>Dimension</b>	Extra seat, cabin dimension
<b>Usefulness</b>	Refrigerator, door opening, steps, radio, sensor systems, steps
<b>Visibility</b>	Front-side-rear windows, visibility of crop bunker, lighting
<b>Working conditions</b>	Air conditioner, dusting
<b>Material quality</b>	Trimming quality



**Fig. 5.** Percentages of the aspects for tractor operators



**Fig. 6.** Percentages of the aspects for combine harvester operators

Table 6 shows the most important aspects for both tractor operators and combine harvester operators. For tractor operators storage space was the most important

issue with a percentage of 15,5%, while for combine harvester operators air conditioner was the most important issue with 22,7%.

**Table 6.** Most important aspects according to tractor and combine harvester machine operators.

Tractor		Combine Harvester	
Aspects	Responses %	Aspects	Responses %
Storage space	15,5	Air conditioner	22,7
Front-side-rear windows	11,1	Front-side-rear windows	13,6
Air conditioner	14,4	Extra seat	9
		Cabin dimension	9
		Lighting	9

For the satisfaction questions in this study Cronbach Alpha reliability coefficient was used. Related coefficient was given in the Table 7. According to this coefficient reliability of the satisfaction questions were found as 0.878 and 0.940 for the tractor and combine harvester questionnaire, respectively. These values show that there is high degree reliability in the study.

**Table 7.** Reliability statistics

	Cronbach's Alpha	N of Items
Tractor cabin	0,878	16
Combine Harvester cabin	0,940	17

## Conclusion

The aim of this study is to incorporate the opinions of the agricultural machinery operators into the cabin

design period to reach comfortable conditions. For this aim a questionnaire was conducted in order to get information about tractor and combine harvester operators' opinions about the comfort of their vehicles. Questionnaire was composed of five ordered scaled and open ended questions. In order to analyse the data collected through the questionnaire cross charts, correlation analysis and reliability analysis were used. For the satisfaction questions in this study Cronbach Alpha reliability coefficient was used. The reliability of the study was high with coefficients of 0.878 and 0.940 for the tractor and combine harvester questionnaires, respectively.

General opinion results show that 36% of tractor operators and 33.3% of combine harvester operators rated their general opinions as "good". 44.6% of tractor operators rated the storage space as "bad". Visibility and the accessibility were the most satisfied issues for the tractor operators with 55.9% and 55.4% percentages, respectively. Cabin dimension and the

storage space were the lowest satisfied issues for combine harvester operators with 33.3% and 30.5% percentages, respectively. Seat comfort has the highest satisfaction degree with 43.7% percentage.

Aspects mentioned by the operators in the open ended questions were classified into different categories for tractors and combine harvesters. Tractor operators generally mentioned refrigerator, storage space, door, steps, steering wheel, accelerator and clutch pedals, these issues were classified in the usefulness category and this category has 27.7%. Among these issues storage space was the most mentioned issue with a percentage of 15.5%. For the combine harvester operators most mentioned categories were the visibility and the working conditions with the same percentage of 27.2%. Among these categories air conditioner was the most mentioned issue with 22.7%.

This study brings the priority suggestion to a design process. The needs must be embodied by the comparison of the issues that were mostly unsatisfied with the previously produced machines according to results of the questionnaire study.

Storage space was determined as the most unsatisfied issue for the tractor operators according to results. Related to this topic, it must be revealed needs of storage space by observing the operators' behaviour in the tractor. When long operation times up to 20 hours a day (Table 1) are taken into account, storage spaces should be specialized according to operator's needs.

Air conditioner was found to be the most unsatisfied issue for combine harvester operators. This issue was also the second unsatisfied issue for tractor operators. This unsatisfaction case of air conditioner can be explained by the operation of the agricultural machines in the dusty environments. In order to understand the main reason of the air conditioner problem, tests should be conducted on the air filters

which are mostly affected by dust, by doing this quality increase should be supplied.

Operator problems related with the tractor and combine harvester machine cabins were determined by this study, and the present findings will be used to support design and development process of new products.

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