Tikrit Journal for Agricultural Sciences (2024) 24 (4): 193-204
DOI: https://doi.org/10.25130/tjas.24.4.16

IRAQI Academic Scientific Journals

ISSN:1813-1646 (Print); 2664-0597 (Online)
Tikrit Journal for Agricultural Sciences
Journal Homepage: http://www.tjas.org
E-mail: tjas@tu.edu.iq

TJAS
Tikrit Journal for Agricultural Sciences

Study of Tractor Vibration during Sowing Operation

Flaieh Hammed Kassar, Ahmed Merza Abood, and Jawad Kadhim Al Aridhee

College of Agriculture, Al-Muthanna University, Al-Muthanna, Iraq

*Correspondence email: flaiehkassar@mu.edu.iq

KEY WORDS:
Tractor vibrations, sowing operation, engine speed, acceleration level

Received: 04/08/2024
Revision: 12/10/2024
Proofreading: 10/11/2024
Accepted: 25/11/2024
Available online: 31/12/2024

ABSTRACT

A field experiment was conducted during Winter Season 2022-2023. The aim of experimental to evaluate the effect of tractor engine speeds and gear position on the vibration levels during sowing operation. The first factor was engine speed of tractor (1000, 1500 and 2000 rpm) and the second factor was the third gear position at two level high and low speed. The measurements were taken at three separate locations (platform, seat and steering wheel) of tractor, in three direction (vertical, horizontal and lateral). The experimental laid out using randomized complete block design (RCBD) with three replications. The results of this study indicated that vibration level was increased as the engine speed of tractor increased at platform, seat and steering wheel in all directions. The change in the gear position setting has a significant effect on the vibration level. The lowest value of vibration acceleration ($2.633 m.s^{-2}$) was obtained at low speed. The maximum acceleration level ($9.472 m.s^{-2}$) was achieved at lateral direction in steering wheel location whereas, the minimum value (**1.1**$00 m.s^{-2}$) was obtained at 1000engine speed and low gear position in horizontal direction in seat location.

دراسة اهتزاز الجرار أثناء عملية البذر

فليح حامد كسار ، احمد مرزة عبود ، جواد كاظم العارضي
كلية الزراعة- جامعة المثنى - العراق

الخلاصة

أجريت تجربة حقلية خلال الموسم الشتوي 2022-2023 لتقييم تأثير سرعة المحرك وسرعة الجرار الارضية عن طريق اختيار السرعة الثالثة لصندوق التروس (ثقيل و خفيف) على مستويات الاهتزاز أثناء عملية البذار. صممت التجربة باستخدام تصميم القطاعات العشوائية الكاملة (RCBD) بثلاثة مكررات. وكان العامل الأول هو سرعة محرك الجرار (1000 و 1500 و 2000 دورة / الدقيقة) والعامل الثاني هو السرعة الثالثة لصندوق التروس وعلى مستويين (ثقيل و خفيف). تم أخذ القياسات في ثلاثة مواقع منفصلة (المنصة، المقعد، وعجلة القيادة) للجرار، في ثلاثة اتجاهات (رأسي، أفقي، وجانبي). أشارت نتائج هذه الدراسة إلى أن مستوى الاهتزاز يزداد مع زيادة سرعة محرك الجرار عند المنصة والمقعد وعجلة القيادة في جميع الاتجاهات. اثر تغيير موضع التروس من الثقيل الى الخفيف تأثير معنويا على مستوى الاهتزاز في الجرار. تم الحصول على أدنى قيمة (2.633 م.ثا$^{-2}$) لتسارع الاهتزاز عند الوضع خفيف لصندوق التروس. تم تحقيق اعلى قيمة(9.472 م.ثا$^{-2}$) لمستوى التسارع للأهتزاز في الاتجاه الجانبي في موقع عجلة القيادة، بينما تم الحصول على ادنى قيمة له(1.100 م.ثا$^{-2}$) عند سرعة المحرك 1000 دورة/دقيقة والوضع الخفيف لصندوق السرع في الاتجاه الافقي في مقعد السائق.

الكلمات المفتاحية: اهتزازات الجرار، عملية البذار، سرعة المحرك، مستوى التسارع

INTRODUCTION

Agricultural machinery workers are exposed to many negative influences during their activities on agricultural fields which can cause harmful effects on the humans (Sameer, Lakhani, *et al.*, 2020). The human body is exposed to different vibrations in everyday life conditions. Entire body vibrations occur when the whole human body is in contact with a vibrational surface (Shahgholi *et al.*, 2019). If the vibrations which come from the tractor or implement are exceed the daily limit of allowed, the driver have to be stop working; otherwise, it would be harmful to health whole body due to the transmission of vibration from the source, the drivers feel some different symptoms, such as abdominal pain, general headaches, chest pain, loss of balance, muscle contractions, shortness of breath, and influence on speech. (Phon Sovatna, 2023; Abood *et al.*, 2023). The engine of agricultural tractors is the main source of vibration. Engine vibration results from the combustion process itself and the mass asymmetry in engine rotating elements (Gravalos *et al.*, 2013). Vibrations that exist on agricultural tractors affect the driver due to lack of comfort and possible health deterioration of drivers (Gialamas *et al.*, 2016) .The major source in vibration development in the lateral axis were the tractors followed by the implements. While, the implements played the major source in the development of vibration in the horizontal axis followed by tractors. Maximum vibration levels recorded in higher engine speed (Sameer Lakhani *et al.*, 2020; Awwad *et al.*, 2023). As engine speed increased with increasing the forward speed has led to increase the vibration of the seat of tractor. The highest acceleration value was obtained at the highest velocity (Fereydooni *et al.*, 2012; Shahgholi, *et al.*, 2019; Mohammadi *et al.*,2023). It is found that engine velocity has a significant influence on increasing vibration level. Engine vibration increasing by engine speed is due to the more frequent mechanical vibration events.

The increase in vibration amplitude was found to have a similar tendency in all different fuels type (Yıldırım *et al.*, 2018). Operation velocity showed significant effects in transmitted vibration in three axes vertical, horizontal and literal from platform feet driver, the lower values were recorded at lower speed and vice versa(Al-Mafrachi, 2016). The vibration level in the lateral axis direction was affected and increased by tractor more than implements. In contrast, the implements played the major factor to increase vibration levels in the horizontal axis and the second factor was tractors (Gialamas *et al.,* 2016). It was noted that the tractor seat is vibrated more in the transverse direction and the increment was due to insufficient seat design and it structure because of the seat is in the middle of the cabin and does not have any dependence on the sides (Shahgholi *et al.,* 2019). The vibration source information differs from vibration signals in different directions and locations. Therefore, it is important to study vibration transfer characteristics in order to respond optimally to the source measurement point location and direction for engine condition monitoring(Li *et al.,* 2023).

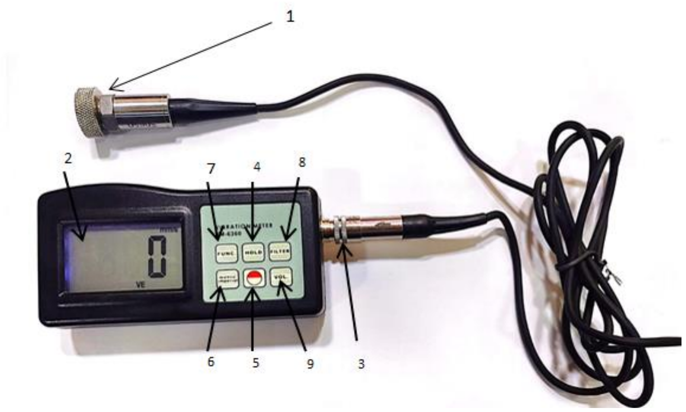
Keeping of all above points a fields experiments were carried out to evaluate the vibration levels during sowing operation under different engine speeds and several gear positions.

MATERIAL AND METHODS

A field experiment was conducted in Al-Najmi region 50km North of Al-Samawa City center in Iraq during Winter Season 2022- 2023 to evaluate the effect of tractors engine speed and gear positions (third gear position at two level high and low speed) on the vibration levels.

Measurement Procedure

Vibration meter VM-6360 (Figure.1) was used to measure the acceleration magnitude at steering, seat and platform locations of Belarus 820 tractor in vertical, horizontal and lateral direction. Observations were taken at three engine speeds in each direction of vibration. The selected engine speed were 1000, 1500 and 2000 rpm while gear position was (third) at two level high and low speed. In order to measure the vibration at vertical direction at seat of driver, the vibration meter sensor was put under the seat. For measuring vibration at horizontal direction in seat position, meter sensor was put back at the chest of seat. While the meter sensor was put at left side of the seat to measure the vibration at Lateral direction with three replicates. The measurements were taken at three separate locations (platform, seat and steering wheel) of tractor . While, to measure the vibration at vertical direction at steering wheel, the vibration meter sensor was put on the steering wheel from upper side. Whereas, to measure vibration at horizontal direction on steering wheel, the meter sensor was put at the in front side of steering wheel. However the meter sensor was put at left side of the steering wheel to measure the vibration at Lateral direction. Similarly, the vibrations at different directions was estimated at platform of tractor. The specification of tractor are explain in the Table 1.



1. Accelerometer 2.Display 3.Input Connector 4.Hold Key 5.Power Key 6.Metric/Imperial conversion 7.Input Key 8.Function Key 9.Filter Key

Figure 1- Vibration meter VM-6360

Table 1-The specification of Belarus 820 tractor used in experiments

Model series	Belarus 820
Engine type	D 243 S
Power, kW (h.p.)	60 (81)
Crankshaft rated speed, rpm	2200
Engine manuf.	Minsk
Power take off speed (rpm)	Continuous I, 540 Continuous II, 1000
Year of made	2012
Seat type	Belarus seat is mechanically suspended with using two spiral springs and shock absorber of double acting type

A mounted type seed spreader was connected to the power take off shaft at rear of tractor. The spreader was made in turkey with capacity of 500L and used for sowing wheat seeds Figure.2.

Figure.2- A mounted type seed spreader connected to the power take off shaft at rear of Belarus 820tractor

Statistical Analysis

The experimental laid out using randomized complete block design (RCBD) with three replications. Experimental data were analyzed using Statistical, Dell Inc. (2016) version 13. Tukey’s test, was used to estimate the significant differences in order to compare the means of parameters at 0.05 level.

RESULTS AND DISCUSSION

The results of this study are and analyzed by using Tukey procedure in order to calculate the statistical difference between the means of each level of engine speed and gear position and illustrated in Table(2) The outcomes showed that the mean of vibration level was increased as the engine speed increased . The maximum acceleration was obtained at 2000 rpm engine speed. Whereas the minimum value was achieved at 1000 rpm engine speed. The mean acceleration values were 5.475, 6.141, 8.075 $m.s^{-2}$ at 1000 rpm of engine speed and 7.825, 9.220 , 9.345 $m.s^{-2}$ at 2000rpm for the vertical , horizontal and lateral direction respectively. The obtained outcomes are almost agreed with findings of Balambica and Deepak, 2017 who estimated the maximum vibration value at the steering wheel at engines speed of 2000 rpm was 17.8 $m.s^{-2}$. Moreover, the results showed that the change in the gear position setting has a significant effect on the vibration level at 5 percent level of significant. The lowest value of vibration was obtained at low position 5.847, 7.400, 8.111 $m.s^{-2}$, while the maximum value was found at the high gear position 7.605, 8.336, 9.472 $m.s^{-2}$ for the vertical, horizontal and lateral direction respectively. These results corresponded to the results of Dahham, *et al.,* 2019, who revealed that the velocity of the tractor had the highest effect on the transmitted vibration from the steering wheel to the hands of the operator for all directions.

Table 2: Influence of Engine speed and Gear position on vibration level in three directions at different locations of tractor

Position of vibration	**Vibration direction**	**Gear position**		**Engine speed (rpm)**		
		Low	high	1000	1500	2000
Steering wheel	Vertical	5.847^{a}	7.605^{b}	5.475^{a}	6.879^{b}	7.825^{c}
	Horizontal	7.400^{a}	8.336^{b}	6.141^{a}	8.241^{b}	9.220^{c}
	Lateral	8.111^{a}	9.472^{b}	8.075^{a}	8.954b	9.345b
Platform	Vertical	6.202^{a}	7.233^{b}	4.591^{a}	7.025^{b}	8.537^{c}
	Horizontal	6.772^{a}	7.475^{a}	3.683^{a}	8.312^{b}	9.375^{c}
	Lateral	7.116^{a}	7.758^{b}	5.179^{a}	8.291^{b}	8.842^{b}
Seat	Vertical	5.288^{a}	6.125^{b}	3.400^{a}	4.650^{b}	9.070^{c}
	Horizontal	2.633^{a}	5.127^{b}	2.391^{a}	3.400^{a}	5.850^{b}
	Lateral	3.397^{a}	5.013^{b}	2.333^{a}	3.979^{b}	6.304^{c}

The influence of interaction between the engine speeds and gear positions on vibration level are given in Figures 3,4,5 . It is revealed that there was a significant effect ($p \leq 0.05$) on the vibration level at the steering wheel in all directions . However, the highest values of acceleration 9.941$m.s^{-2}$ was obtained from 2000 rpm of engine speed and the high gear position at lateral direction. Whereas, the lowest value of vibration level 4.225 $m.s^{-2}$ was obtained from 1000 rpm of engine speed and the low gear position at vertical direction .

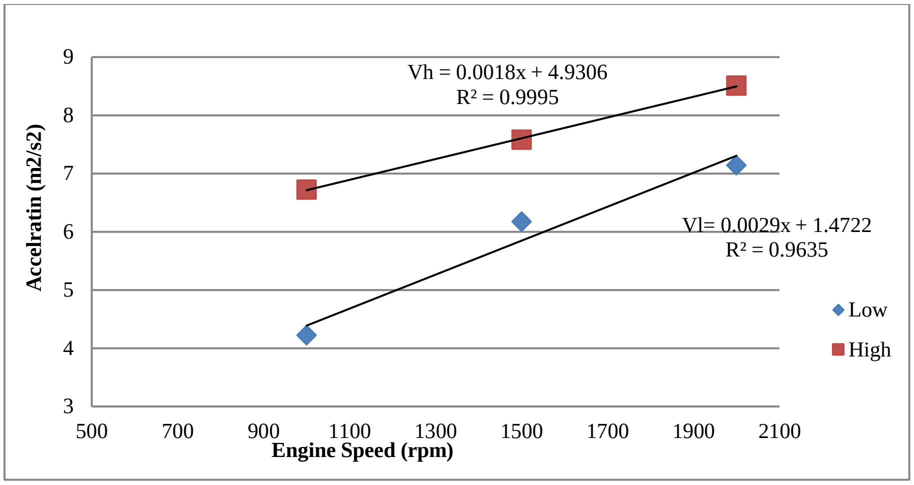


Figure 3: The interaction influence of engine speed and gear position on vibration level (in vertical direction) at tractor steering wheel

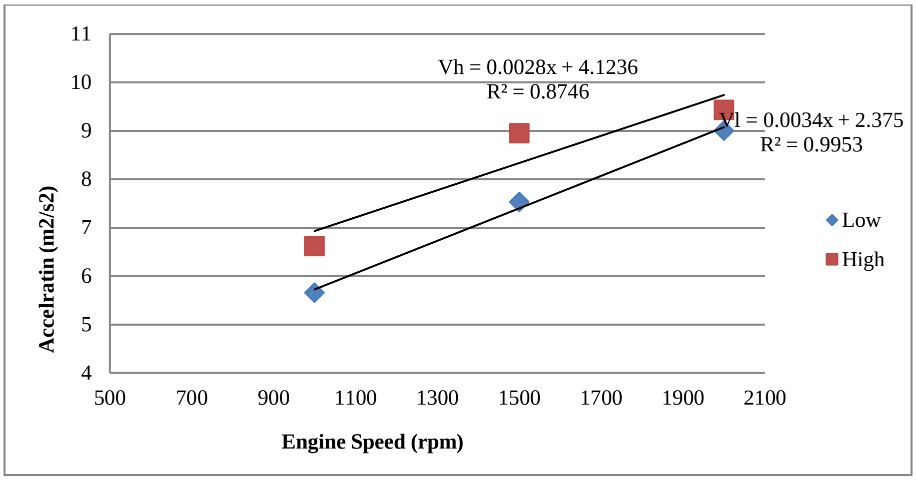


Figure 4: The interaction influence of engine speed and gear position on vibration level (in horizontal direction) at tractor steering wheel

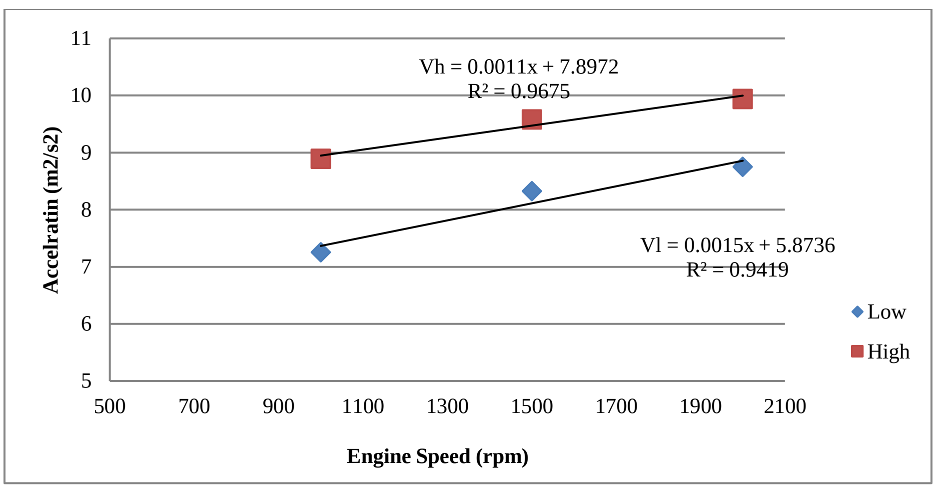


Figure 5: The interaction influence of engine speed and gear position on vibration level (in lateral direction) at tractor steering wheel

The effect of vibration during sowing operation at tractor platform was assessed using acceleration parameter. It is clear that there is a significant effect of engine speed on vibration levels. The means of acceleration value were presented in Table 2 . The results indicated that the change in engine speed has a considerable effect ($p \leq 0.05$) on vibration levels . The maximum value of mean acceleration were 8.537, 9.375, 8.842 $m.s^{-2}$ at 2000 rpm engine speed for the vertical , horizontal and lateral direction respectively. Whereas, the minimum value of mean acceleration were 4.591, 3.683, 5.179 $m.s^{-2}$ at 1000 rpm engine speed for the vertical, horizontal and lateral direction respectively. Moreover, The results showed that the change in the gear position setting has a significant effect on the vibration level ($p \leq 0.05$). The lowest value of vibration was optioned when the sowing operation at low gear position 6.202, 6.772, 7.116$m.s^{-2}$, whereas the maximum value was obtained at the high gear position 7.233, 7.475, 7.758$m.s^{-2}$ for the vertical , horizontal and lateral direction respectively. The current outcomes agreed with Al-Mafrachi, 2016 who noted that the higher forward speed recorded higher values of vibration and this could be due to increase tractor speed led to increase transmitted vibration from soil to tires after that to tractor platform. The interactions between the gear positions and engine speeds are presented in Figures 6,7,8 which showed that there was a significant effect ($p \leq 0.05$) on the vibration level at the tractor platform. However, the highest values of acceleration 9.475 $m.s^{-2}$ was obtained from the combination of 2000 rpm of engine speed and the high of gear position at lateral direction. Whereas, the lowest value of vibration level 3.475 $m.s^{-2}$ was obtained from the combination of 1000 rpm of engine speed and the low of gear position at horizontal direction.

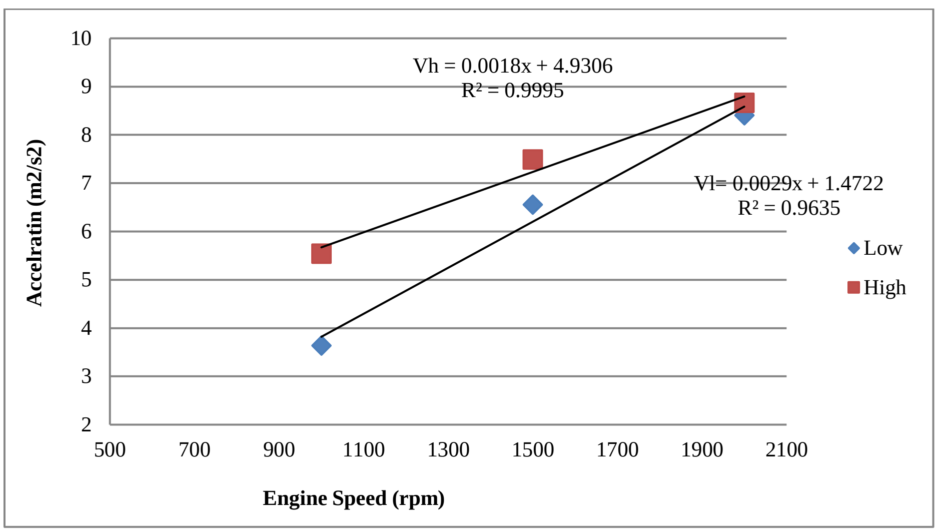


Figure 6: The interaction influence of engine speed and gear position on vibration level (in vertical direction) at tractor platform

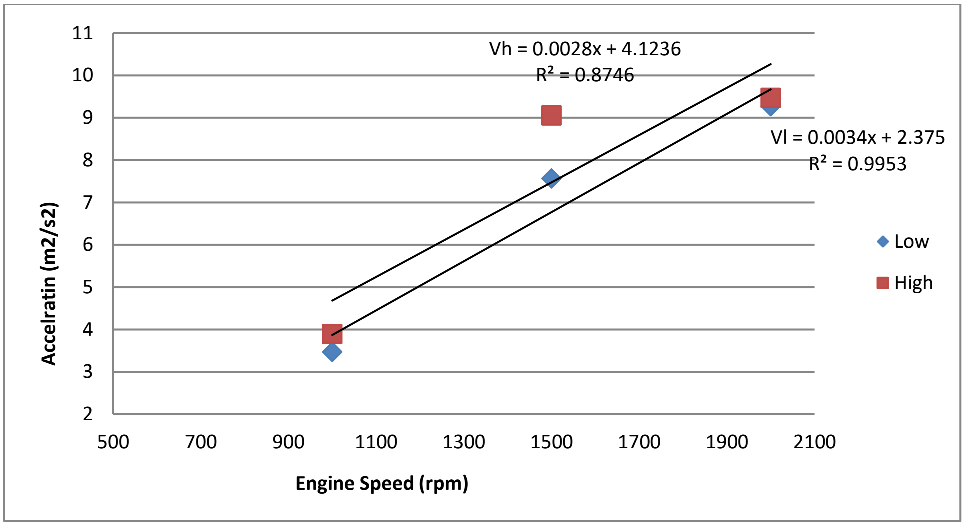


Figure 7: The interaction influence of engine speed and gear position on vibration level (in horizontal direction) at tractor platform

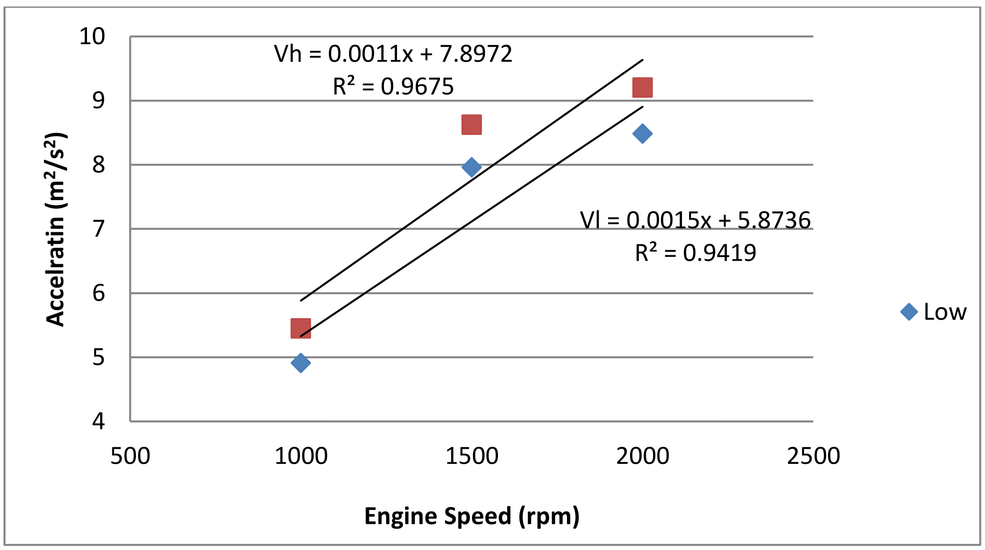


Figure 8: The interaction influence of engine speed and gear position on vibration level (in lateral direction) at tractor platform

The value of vibration at the tractor seat during sowing operation which probably transfer to various parts of the body. The presented results in Table 2 indicated that there was a statistically significant increase ($p \leq 0.05$) in vibration level at tractor seat when increased the engine speed from 1000 to 1500 and then to 2000 rpm. The highest value of mean acceleration 9.070, 5.850, 6.304m.s^{-2} , were recorded during engine speed of 2000. Whereas the lowest value of mean acceleration 3.400, 2.391, 2.333 m.s^{-2} were obtained from the engine speed of 1000 rpm for the vertical , horizontal and lateral direction respectively. In addition, there was a considerable significant effect on the vibration level by changing the gear position setting. The lowest value of acceleration was obtained when the sowing operation at low gear position 5.288, 2.633, 3.397m.s^{-2}, whereas the highest value was obtained at the high gear position

6.125, 5.127, 5.013 m.s^{-2} for the vertical , horizontal and lateral direction respectively. The present outcomes corresponded to the results of Ahmadian, *et al* 2014 and Nag, *et al.*, 2020 who noted that increasing engine speed, led to increase the vibration RMS values at the seat position for all the gear ratios. The reason for this increment might be attributed to increasing of combustion strokes number and the piston shocks per unit time. The interaction effect between engine speed and gear position illustrated in Figures 9,10,11 indicated that a significant increase ($p \leq 0.05$) was observed in the vibration level at tractor seat in all direction. The maximum value of acceleration in horizontal direction was recorded at engine speed of 2000 rpm and high gear position (9.333 m.s^{-2}), while the minimum value in horizontal direction (1,100 m.s^{-2}) was observed from the combination of 1000rpm engine speed and low gear position.

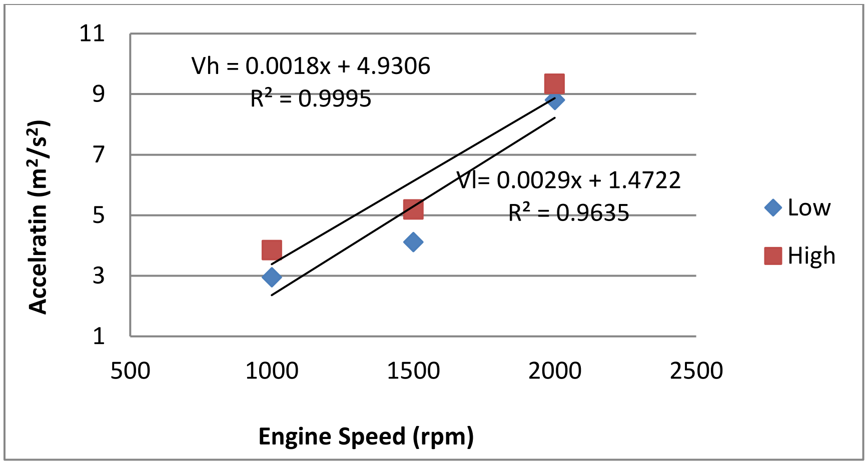


Figure 9: The interaction influence of engine speed and gear position on vibration level (in vertical direction) at tractor seat

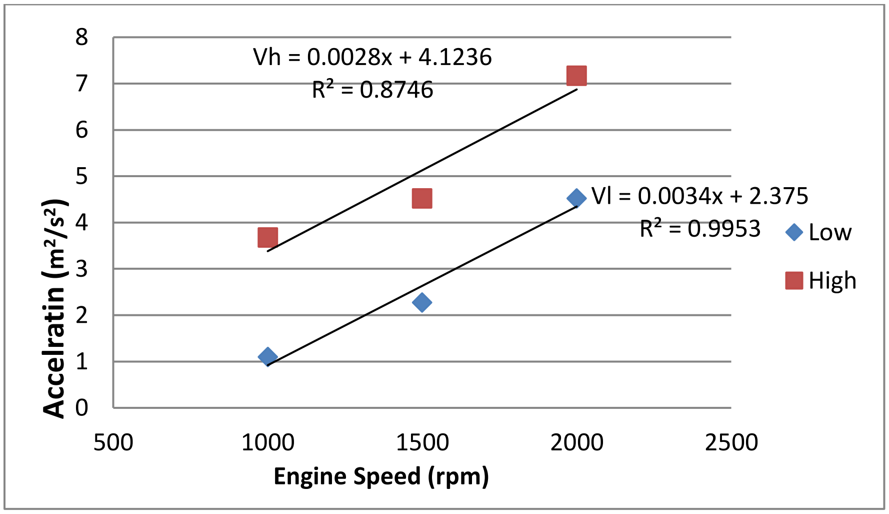


Figure10: The interaction influence of engine speed and gear position on vibration level (in horizontal direction) at tractor seat

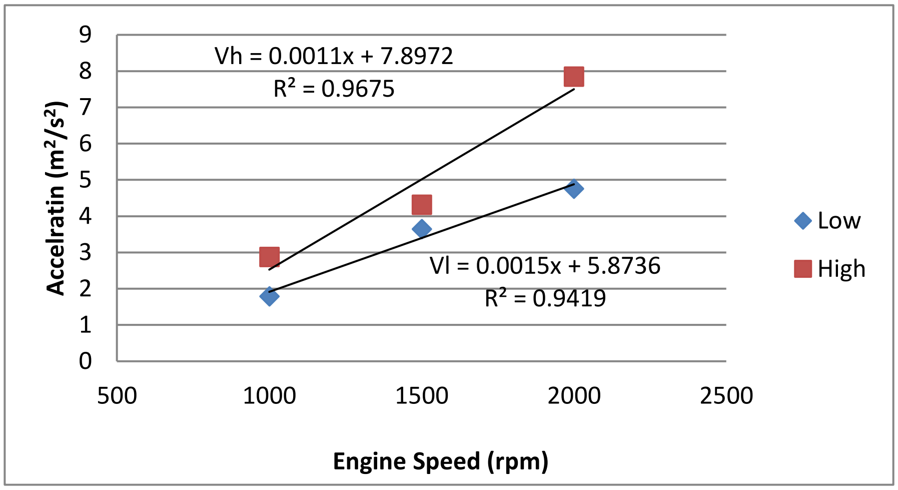


Figure 11: The interaction influence of engine speed and gear position on vibration level (in lateral direction) at tractor seat

CONCLUSION

The outcomes of this study indicate that the vibration levels at steering wheel, platform, and seat of Belarus tractor were higher than permissible. The vibration level is worsened by increasing engine speed and using high gear positions. In all tractor-selected locations, the highest acceleration level in vertical, horizontal, and vertical directions was observed at the highest engine speed and high gear position. The lowest value of vibration acceleration ($2.633 m.s^{-2}$)was obtained at low speed. The highest acceleration level ($9.472 m.s^{-2}$) was achieved at lateral direction in steering wheel location while, the lowest value ($1.1 m.s^{-2}$) was obtained at 1000engine speed and low gear position in horizontal direction in seat location. There is an urgent need for further research to develop a suitable schedule for operating the tractor so that the tractor driver is given a break after each operation in order to reduce the stress on the driver resulting from vibrations.

REFERENCES

Abood, A. M., Al Aridhee, J. K., Kassar, F. H., Łysiak, G., & Dakhil, M. M. (2023, August). Assessment of Body Discomfort and Physiological Cost of Tractor Drivers during Tillage Operation with Mould Board Plough. In IOP Conference Series: Earth and Environmental Science, 1225 (1), p. 012103). IOP Publishing.

Ahmadian, H., Hassan-Beygi, S. R., & Ghobadian, B. (2014). Investigating a power tiller handle and seat vibration on transportation mode. Agricultural Engineering International: CIGR Journal, 16(4), 194-206.

Al-Mafrachi, A. A. H. (2016). Measuring Vibration At Tractor Platform, Steering Wheel And Seat Effective Amplitude Transmissibility Factor During Operation Tillage. *Iraqi Journal Of Agricultural Sciences*, 47(1): 365-378.

Awwad, A. A., Hilal, Y. Y., & Rajab, R. H. (2023, July). The Effect of Diesel Fuel Improvers on the Vibrations, Noise and Fuel Consumption of the Agricultural Tractor Engine During the Tillage Process. In IOP Conference Series: *Earth and Environmental Science*, 1213 (1), 012098). IOP Publishing.

Balambica, V., & Deepak, V. (2017). Study and analysis of reducing hand vibration in a tractor. *International Journal of Pure and Applied Mathematics*, 116(18), 275-279.

Dahham, G. A., Muhamed, S. T., & Saleh, S. M. (2019). Practical study for the effect of speed, direction of acceleration and type of machine on vibrations transferred to the steering wheel horticulture tractor type (goldoni). Engineering, 11(1), 48-58.

Fereydooni, M., Lorestani, A. N., Rabbani, H., & Javadikia, P. (2012). Measurement and analysis of vibration of operator in Universal 650, Massey Ferguson 285 & MF 299 Tractors. International Journal of Mechanics and Applications, 2(5), 88-92.

Gialamas, T., Gravalos, I., Kateris, D., Xyradakis, P., & Dimitriadis, C. (2016). Vibration analysis on driver's seat of agricultural tractors during tillage tests. *Spanish journal of agricultural research*, 14(4), 210-220.http://dx.doi.org/10.5424/sjar/2016144-9664

Gravalos, I., Loutridis, S., Gialamas, T., Avgousti, A., Kateris, D., Xyradakis, P., & Tsiropoulos, Z. (2013, September). Vibrational behavior of tractor engine hood. *In Proceedings of the 5th International Scientific Conference on Trends in Agricultural Engineering* (TAE 2013), Prague, Czech Republic, 181-185.

Li, J., Li, X., Li, Y., Zhang, Y., Yang, X., & Xu, P. (2023). A new method of tractor engine state identification based on vibration characteristics. Processes, 11(2),1-18

Sameer Lakhani, Nirav Butani and Anil Kavad. 2020. Study of the Noise and Vibration Characteristics of an Agricultural Tractor. Int.J.Curr.Microbiol.App.Sci. 9(07): 3187-3194. doi: https://doi.org/10.20546/ijcmas.2020.907.372

Shahgholi, Gholamhossein; Fazeli, Sedagat; and Mousavi, Saleh Harami (2019) "Vibration Evaluation of the Driver's Seat of MF 285 Tractor in Conducting the Tillage Operations," Emirates Journal for Engineering Research: Vol. 25 : Iss. 1.

Yıldırım, H., Özsezen, A. N., & Çınar, A. (2018, June). Vibration and noise depending upon engine speed in a diesel engine fueled with biodiesel. In 6th European Conference on Renewable Energy Systems, Istanbul, Turkey.

Phon Sovatna, (2023). Investigation of Vibration Characteristics of a Hand Tractor and Detection of Target Vibration Reference Points based on Transfer Path Analysis Technique (Doctoral dissertation, Kyushu University).

Dell Inc. (2016). Dell Statistica (data analysis software system), version 13. Software.dell.com

Nag, P. K., Gite, L. P., Nag, P. K., & Gite, L. P. (2020). Ergonomics Application in Design of Workplace of Tractors and Power Tillers. Human-Centered Agriculture: Ergonomics and Human Factors Applied, 333-351.

Mohammadi, A., Ghamary, B., Jahanbakhshi, A., & Shahidi, R. (2023). The driver responses to the vibration of tractor. Agricultural Engineering International: CIGR Journal, 25(3).66-77