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Research Paper

Noise, vibration and performance evaluation of power weeder

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ABSTRACT

The study of power weeder was conducted at Research Experimental Farm, College of Agricultural Engineering & Technology, SKUAST-K. Excessive noise of rotary weeder during farm operation may cause serious health problems to agricultural workers. This paper ~~shows~~ highlighted the case study on noise (SPL), vibration (HAV) and field evaluation of popularly used power tiller in the Kashmir Valley. It was observed that average SPL of power weeder at by-stander position and weeding operation were 72.42, 74.21, 81.83 & 83.25dB &83.12, 86.20, 92.25 & 94.57 dB at four levels of engine rpm ¼, ½, ¾ and full respectively. The weeding and field efficiency of power weeder varied from 82.50 to 85.10 % and 81.30 to 82.32 % at a fuel consumption rate of 0.78 to 1.05 litre per hour.

Key words: Effective field capacity, handle arm vibration, noise, operator health, power weeder, weeding efficiency

Agricultural mechanization in agriculture plays a catalytic role that can enable higher performance and productivity, converting many former subsistence farmers working on small farms using human and animal power into dynamic commercial farmers using mechanized sources of agricultural energy. Tractors and power tillers/weed mowers have recently been used to perform various agricultural operations such as tillage, puddle tillage, intercropping, crop protection, irrigation, harvesting, and threshing. Timely operation is an important constraint in agriculture. In agricultural work, the fatigue and discomfort people experience are not only due to physical work, but also to noise and vibration. Exposure to excessive noise and vibration can cause acute or chronic health problems.

Noise is commonly defined as unwanted sound. Sound is audible and perceptible to the ear at a frequency of around 15 to 16,000 Hz. Noise has several undesirable effects. In agriculture, noise is caused by tractors, power weeders, power tillers, crop harvesters, threshers and plant protection equipment's. Noise exposure (at a level of 90 dB) for 40 hours per week is considered harmless, and noise levels above 90 dB at 8 hours per week exposure inevitably lead to noise induced hearing loss (NIHL). Most of the power weeder / tillers operators suffer from noise-induced hearing loss and vibration at the time of operation in the field. The inner workings of our ears are much sensitive, and can become damaged if not handled carefully. The louder the sound, the stronger the vibration. Larger vibrations damage the sensitive parts of our ears, which is why loud noises are often uncomfortable and sometimes painful. Ruptured eardrums and conditions like acoustic shock are incredibly painful and can permanently damage a person's hearing, affecting not only their ability to perform everyday activities but also influence the quality of life.

Excessive vibrations felt at the handle are observed as important deficiencies in field operation of the tiller (Pawar, 1978). The vibration from the handle of the hand tractor is transmitted to the hands, arms and shoulders. Vibrations transmitted to the operator cause discomfort and pain (Tewari *et al.,* 2004). Aches and pains lead to early fatigue. (Christensen *et al.*, 2000) reported that time-integrated fatigue can lead to different types of injuries during machine operation. Practical experience shows that the human body is subjected to significantly greater stress in different field conditions when driving the tiller. The operator of a tiller is exposed to noise, dust, vibration, exhaust fumes, rain and sunshine, etc. The vibration of power weeder enters into the driver's body through handle. Long-term exposure of this vibrations may lead to health risks among the drivers

(Singh *et al*, 2022).The vibration level of power tiller increased with an increase in engine speed in the stationery and transport mode and vertical vibration was significantly higher at the tip of the handle of a power tiller which has direct contact with the operator hand arm system (Mamansari, 1998). The power weeder is a multi-purpose hand tractor designed primarily for rotary tilling and other farm operations. It is the main mechanical resource for small and medium size farms in Kashmir. The main aim of present study was to find out the noise, vibration and field evaluation of popularly used power weeder in the Kashmir Valley. The study was conducted at Research Experimental Farm, College of Agricultural Engineering and Technology, SKUAST-Kashmir. The field size, moisture content and type of soil at which the weeder was evaluated was 178 m^2, 38 %, and clay loam respectively.

MATERIALS AND METHODS

Moisture Content: Digital soil moisture meter was used to find out the available soil moisture content in the selected field at different locations.

Bulk density: *Bulk density* is defined as the dry weight of soil per unit volume of soil (Al-Shammary *et al*, 2018). It is an indicator of soil compaction.

$$\text{Bulk density (g/cm}^3) = \frac{Ms}{(Ms - Msw)} \times d_w \qquad \text{(i)}$$

where,

M_s is the weight of the soil sample after being air dried at 105 ◦C for about 24 h in g,
M_{sw} is the weight of the sample in water in g
d_w is the water density (1 g/cm^3)

Noise Measurement: The tests were carried out with power weeder (Table 1) in the clay loam soil to investigate the noise level in the stationary condition and weeding operation. There were no obstacles such as trees, buildings, solid fences, rocks or other objects within a radius of 50 m. Temperature and humidity were measured with a hygrometer and anemometer was used for wind speed during the test.

Table 1: Specification of power weeder used in the study

Model	**KRH-100B**
Serial Number	GX200-2037937
Rated Speed	3800
Rated Power, kW	3.23
Cylinder	1
No. of flanges	6 (3+3)
Type of flanges	Square
Distance between two flanges, mm	120
Overall length of rotor, mm	810

The experimental conditions were suitable to perform noise measurement experiments according to the test codes IS-12180:2000, ISO-7216:1992, Table 2. The noise level was measured at the by -standers position & operator's ear level at four levels of engine rpm with the help of digital sound level meter (Power tiller test Code is 9935:2002).

Table 2: Permitted exposure levels (Recommended by OSHA)

Duration (hrs./day)	Sound level (dB)	Duration (hrs./day)	Sound level (dB)
8	90	1.5	102
6	92	1.0	105
4	95	0.50	110
3	97	0.25	115
2	100	-	>115

Vibration Measurement: A vibration meter (HVM200 Larson Davis) with built in Wi-Fi that was used to measure hand-arm, whole body and general vibration. It includes the metrics and frequency weightings needed to measure human vibration. This 3-channel meter meets the requirements of ISO 8041:2005 to measure vibration as per ISO 2631-1, 2 & 5 and ISO 5349 in support of the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) and the directive 2002/44/EC. A HVM 200 mobile application was installed in mobile phone for display the reading of vibration of weeder. Handle arm vibration (HAV) during weeding operation was measured at left and right handle grip at four level of engine rpm.

Fig.1: Measurement of sound pressure level at operator's ear level during weeding operation

Performance of Power Weeder:

Field capacity: Field capacity is the ratio of actual average rate of field coverage by the machine to the total time during operation (Hunt, 2008).

$$\text{AFC (ha/h)} = \frac{A}{T} \qquad \text{(ii)}$$

A = Total weeding area, ha

T = Total operating time required for weeding, h

Weeding Efficiency: Weeding efficiency of weeder was calculated by using following formula.

$$\text{W.E.} = \frac{W1-W2}{W1} \times 100 \qquad \text{(iii)}$$

where,

W_1 = number of weeds before weeding

W_2 = number of weeds after weeding

Field efficiency: The field efficiency is the ratio of effective field capacity and theoretical and actual field capacity of the machine. It was calculated by using the following suggested by (**Hunt, 2008)**

$$\text{F.E.} = \frac{\text{Effective field capacity, ha/h}}{\text{Theoretica l field capacity, ha/h}} \times 100 \qquad \text{(iv)}$$

Fuel Consumption (lit/h): The measurement of the weeder fuel consumption was measured by filling the weeder fuel tank before and after a weed operation, noting the area covered, the time and the amount of fuel used. Fuel economy was estimated by keeping the machine on a level platform and filling the fuel to the full capacity mark with the help of the measuring cylinder. The required amount of fuel for refueling the fuel tank after one hour of continuous operation up to the full level mark was calculated (Khan *et al* 2015).

RESULTS AND DISCUSSION

Noise Analysis: The noise of power weeder was measured in accordance with the guidelines ISO-1999 and IS-5994 standards. First gear was selected for weeding operation. Weather parameters like temperature humidity and wind velocity were measured with a hygrometer and anemometer, respectively. During the test temperature, humidity and wind speed were observed 24ºC, 55% and 3.92 km/h respectively. Before weeding operation, rpm of weeder was measured by tachometer and marked on accelerator by the permanent marker at 950, 1900, 2850 & 3800 rpm, Fig. 2. The average SPL of power weeder at by-stander position was observed to be 72.42, 74.21, 81.83 and 83.25 at four level of engine rpm ¼ (ER1-950 rpm), ½ (ER2-1900 rpm), ¾ (ER3-2850 rpm) and full (ER4-3800 rpm). The sound level readings were recorded in digital sound level meter by holding it at operator's ear level, approx. 1 m from the ground level for 30 seconds. The average value of sound pressure level during weeding operation were observed as 83.12, 86.20, 92.25 & 94.57 dB at four level of engine rpm respectively at operator's ear level. It was noticed that the rate of SPL was slower at ¼thand ½ engine rpm and higher as the engine speed increased to 2850 to 3800 rpm. Similar trend of SPL at operator's ear level and bystander position was observed by Verma *et al*, 2015.

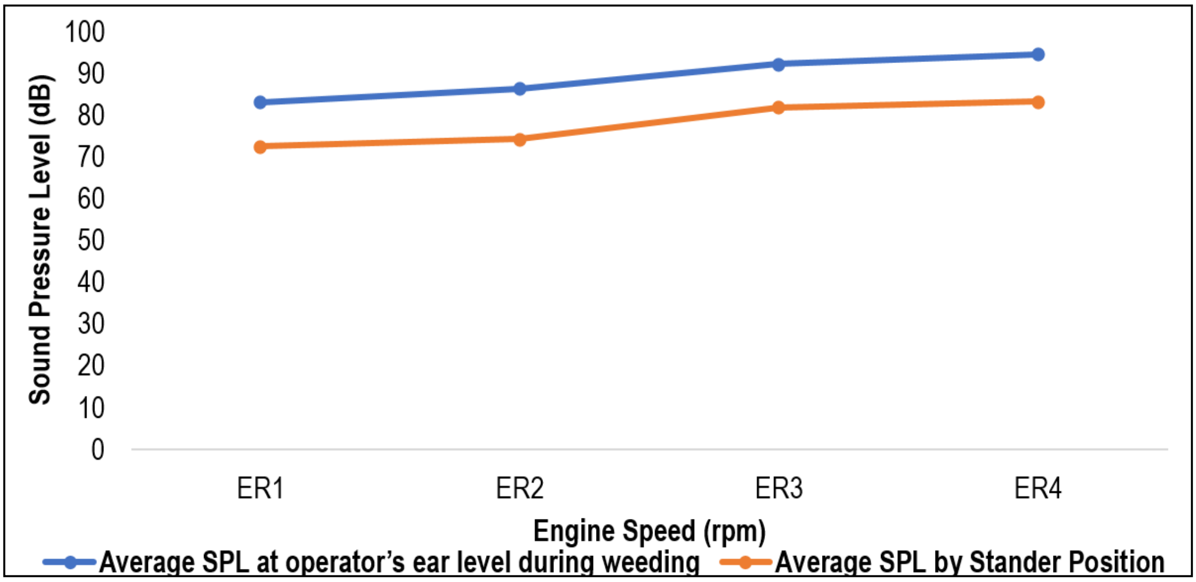

Fig. 2: SPL at operators' ear level and bystander position during weeding operation at four level of engine speeds

Vibration Analysis: The Handle Arm Vibration (HAV) was measured at the handle-grip according to the guide lines issued in ISO 5349 (1986).The influence of different engine speeds on the handle -arm vibrations during the weeding operation. In horizontal direction, the lowest value of HAV of 78 µ at left handle arm, when the engine speed was (¼) 950 rpm. In vertical direction, the highest value of HAV of 185µ was recorded at right handle arm at full engine speed; it was 3800 rpm, Table 3. The magnitude of HAV increased linearly with the increase in engine rpm from ER1 to full. It was observed that vibration transmitted to the hand increased with an increase in engine speed. Similar trend of HAV was found by Sam and Kathirvel, 2006.

Table 3: Handle arm vibration (HAV) during weeding operations

S. No.	Location	Engine rpm	Horizontal Direction (X) (µ)	Vertical Direction (Y) (µ)
1	Handle arm (left)	¼	78.00	80.50
		½	87.26	95.40
		¾	97.80	125.20
		Full	110.10	165.78
2	Handle arm (right)	¼	81.13	95.26
		½	85.20	101.23
		¾	98.20	127.65
		Full	109.20	185.20

Evaluation of power weeder: The field evaluation of weeder was conducted in clay loam soil at the Research Experimental Farm, College of Agricultural Engineering & Technology, Sher-e-Kashmir University of Agricultural sciences and technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir, data sheet of field test is presented in Table 4. The average field capacity of weeder increased from 0.069 – 0.106 ha/h, when speed of operation increased from 0.80 to 1.20 kmph. Average weeding and field efficiency of 82.50 to 85.10 % and 81.30 to 82.32 % were observed at four levels of engine speeds. It was also observed that power weeder required 9.36 to 14.26 hours to complete the weeding of one hectare land.

Table.4: Data sheet of field test (dry land operation) of power weeder

S. No	Parameter	Particular
1.	Type of soil	Clay loam
2.	Type of weed	Seasonal weeds
3.	Height of weed, cm	5.5-15.5
4.	Average Soil moisture, %	25-32
5.	Average Bulk density of soil, /cm3	1.93 – 2.1
6.	Average Speed of operation, km/h	0.80 – 1.20
7.	Average depth of cut, cm	5.10 - 7.70
8.	Average Width of cut (m)	0.87 - 0.89
9.	Average Area covered, ha/h	0.069 – 0.106
10.	Average Time required for one ha	9.36 – 14.36
11.	Average Fuel Consumption, l/h	0.78 – 1.05
12.	Average Fuel Consumption, l/ha	8.03 – 15.07
13.	Average Weeding efficiency (%)	82.50 – 85.10
14.	Average Field efficiency (%)	81.30 – 82.32

Fuel consumption: Fuel consumption of power weeder increased from 0.78 to 1.05 l/h with an increase in engine speed (ER1 to full) and depth of cut (5.10 to 7.70 cm), Fig. 3. It has been observed that increase in the engine speed and depth of cut demanded more fuel to be supplied to the engine to produce more engine brake horse power (BHP). Hence, the fuel consumption increased with an increase depth of cut and engine speed of the power weeder. A similar trend was observed by Sujit. *et al.,* 2022.

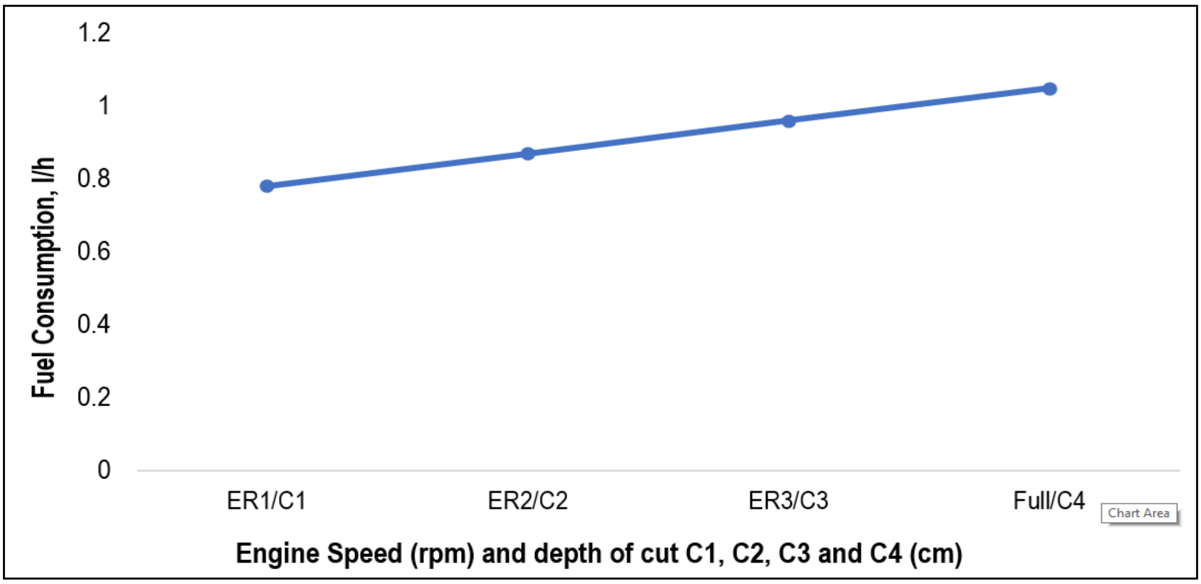

Fig.3: Effect of engine speed and depth of cut on fuel consumption

CONCLUSION

The SPL and HAV rises with the increase in engine rpm. At ¼ and ½ engine speeds, there is no need of intervention as the value was below 85 dB and other two engine speeds i.e., at ER3 and full requires appropriate intervention to protect the operator. The SPL of the rotary weeder with in the permissible limits as recommended by OSHA, 2010. Average weeding efficiency of weeder was observed from 82.50 to 85.10 %. From the study, it can be concluded that the appropriate intervention can help to protect the operators from the hazards of noise and vibration

REFERENCES

Akter, Y., Akbar, M. A, Shahjalal. M. and Ahmad T.U. 2004. Effect of urea molasses multi-nutrient blocks supplementation of dairy cows fed rice straw and green grasses on milk yield, composition, live weight gain of cows and calves and feed intake. *Pakistan Journal of Biological Sciences,* **7**:1523-1525.

Alam, M. G. S., Azam M. S. and Khan M. J. 2006. Supplementation with urea and molasses on body weight, milk yield and onset of ovarian cyclicity in cows. *Journal of Reproduction and Development*, **52**:529-535.

Al-Shammary A A G, Kouzani A Z, Kaynak A, Khoo S Y, Norton M, Gates W. 2018. Soil bulk density estimation methods: A review. *Pedosphere*, **28**: 581–596.

Bandla, S. and B. N. Gupta. 1997. Rumen fermentation, bacterial and total volatile fatty acid (TVFA) production rates in cattle fed on urea-molasses-mineral block licks supplement. Anim. Feed Sci. Technol. **65**:275-286

Christensen, E.H., Sjogaard, K., Pilegaard, M., Olsen, H.B., 2000. The importance of hand tractors. *Biosystems Engineering,* **89**: 1-11.

Hunt, D. 2008. A text book of Farm Power and Machinery Management. Waveland Press.

Khan, Kalay, Moses, S.C., Ali, M. Nayeem and Kumar, Ashok., 2015. Effect of Rotor Speed of Vertical Axis Rotary Harrow on Mean Weight Diameter of Soil Aggregates and Fuel Consumption. *Trends in Biosciences,* **8**: 2845-2849.

Mamansari, D. U., 1998. Ergonomic evaluation of a commonly used power tiller in Thailand. Unpublished Ph.D. Thesis. *Asian Institute of Technology, Bangkok*, Thailand.

Occupational Safety & Health Administration (OSHA) U.S. 2010. Department of Occupational Safety & Health Administration Labor 200 Constitution Avenue, NW Room Number N3626 Washington.

Pawar, J.G., 1978. Investigation of Human Energy Requirements for Power Tiller Operators. Unpublished M. Tech. Thesis, *Department of Agricultural Engineering*, Punjab Agricultural University, Ludhiana, India

Sam Bini and Kathirvel K. 2006. Vibration Characteristics of Walking and Riding Type Power Tillers.*Biosystems Engineering*, **95**: 517–528

Singh Amandeep, Samuel Siby, Singh Harwinder, Singh Jagmeet, Prakash Chander and Dhabi Yash Kumar. 2022. Whole Body Vibration Exposure among the Tractor Operator during Soil Tillage Operation: *An Evaluation using ISO 2631-5 Standard, Shock and Vibration Hindawi*, 1-8

Sujit,S., Chattopadhyay Partha Sarathi and Das K. 2022. Drawbar performance of a power tiller on a sandy loam soil of the Nadia district of West Bengal. *Research in Agricultural Engineering*, **68**: 41–46.

Tewari, V.K., Dewangan, K.N., Karmakar, S., 2004. Operator’s fatigue in field operation the work/rest pattern as a risk factor in repetitive monotonous work. *International Journal of Industrial Ergonomics*, **25**: 367-373.

Verma, Ajay, Kumar Guru., Pandey Prabhat & Kumar Mukesh., 2015. Assessment of Duration of Exposure to Noise by the Operators in Power Tiller Workplace. *Nature Environment and Pollution Technology*, **14**: 485-492.