The Pharma Innovation Journal 2022; 11(12): 3505-3509

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 3505-3509

www.thepharmajournal.com
Received: 06-10-2022
Accepted: 09-11-2022

H Manjunath
Research Associate, (Ag. Engg.), Regional Agricultural Research Station, ANGRAU, Nandyal, Andhra Pradesh, India

M Veerangouda
Professor and Registrar, University of Agricultural Sciences, Raichur, Karnataka, India

Sushilendra
Associate Professor, Department of Farm Machinery and Power Engineering, CAE, Raichur, Karnataka, India

Vijayakumar Palled
Associate Professor, Department of Renewable Energy Engineering, CAE, Raichur, Karnataka, India

GV Srinivasa Reddy
Associate Professor, Department of Irrigation and Drainage Engineering, CAE, Raichur, Karnataka, India

Channabasavanna AS
Dean (Agri.), College of Agriculture, Bheemarayanagudi, UAS Raichur, Karnataka, India

Corresponding Author:
H Manjunath
Research Associate, (Ag. Engg.), Regional Agricultural Research Station, ANGRAU, Nandyal, Andhra Pradesh, India

Ergonomic characteristics of a power tiller by conventional method of puddling

H Manjunath, M Veerangouda, Sushilendra, Vijayakumar Palled, GV Srinivasa Reddy and Channabasavanna AS

Abstract
The ergonomic aspects of power tiller are of great importance as the operator of a power tiller has to endure various environment and stress. Excessive noise level is the important shortcomings in ergonomic aspects of power tiller. The sound pressure level meter was used for measurement of sound pressure or noise level of power tiller at field condition. The parameters are selected for the field evaluation of power tiller with different forward speeds, rotary speeds and type of blades like 1.8, 2.1 and 2.4 km h^{-1}, 220, 260 and 300 rpm and C and J type of blades, respectively. The results found that maximum noise at bystanders position and operators ears position were 88.40 dB(A) and 97.00 dB(A) was recorded at 300 rpm of rotary speed for C type of blade.

Keywords: Hand transmitted vibration noise at bystanders position, noise at operators ears positions and power tiller

1. Introduction
Power tiller is a prime mover in which direction of travel and its control for field operation is performed by the operator walking behind it. Power tiller is walking tractor mostly used for rotary cultivation in puddle soil and can replace the animal power more effectively and help in increasing demand for human labour. The small and marginal farmers form major user for custom hiring of power tiller and it used for all farm operations like puddling and primary tillage operations. The machine provides opportunities for self-employment in rural areas.

Puddling leads to increasing its water holding capacity due to increase in micro porosity of soil, makes manual transplanting easier by reducing shear strength of soil. Resulted reduction in air filled pore volume by replacing water, better weed control due to lack of oxygen and shift in weed flora. It improves soil fertility and productivity of the soil, highest yield is generally reported from wetland cultivation. Therefore, a great prominence has been on development of suitable set of practices and machinery for wetland rice cultivation. Paddy crop requires a large amount of water and hence, to reduce irrigation requirement, puddling is to be done in rice soils before sowing or transplanting.

Agricultural machineries, especially those controlled by operator's hand, transmit high level of vibrations to operators hand and body. In spite of applications and benefits, power tillers generate high level of vibrations due to their single cylinder diesel engine and lack of vibration damping facilities. The operator of a power tiller has to endure various environmental stresses. The mechanical vibration is the most important parameter that affects sensitivity and reaction rates of the operator. Besides, the power tiller operators work in harsh environment and this lead to draw attention for importance of ergonomic characteristics. Long term of continuous working with power tillers, creates movement disorders, damage to various body organs including the ear, spine and gastrointestinal disorders, and neurological diseases (Salokhe *et al.*, 1995; Tiwari *et al.*, 2004) [7, 11]. In addition, work quality loss was also observed. In an investigation regarding the ergonomic conditions of an 8-hp power tiller, 200 farmers and 100 extension workers were studied. The study revealed that noise and vibration of the power tiller played an important role in damages experienced by them.

Many experiments were carried out for investigating the power tillers vibration and tractors vibration. Taghizadeh-Alisaraei *et al.* (2007) [10] assessed vibrations of a 7.5-hp walking power tiller. Experiments were conducted at stationary condition, ploughing operation and transporting. The vibration acceleration was measured at locations of chassis and handle of the power tiller as well as the arm and chest of the driver at the vertical, lateral and longitudinal directions.

The results revealed that the vibration RMS values increased in all the location with increasing engine speed. It was observed that the dominant frequency of vibration in all directions and locations were equal to engine speed (revolution per second).

Sam and Kathrivel (2006) [8] examined the vibration characteristics of walking and riding type power Tillers. The results indicated that machine vibration increased with an increase in engine speed and major excitation of the vibration of the power tiller was the unbalanced inertial force of the engine. The walking type power tiller showed higher hand transmitted vibration than the riding type during rototilling, whereas the riding type power tiller exhibited higher hand transmitted and whole body vibrations during the transport mode. It was observed that, if the power tiller is used at least 4 h day^{-1} at the forward speed of 2.4 kmh^{-1}, these disorders would appear in 4 year, for 10 per cent of the operators, under usual working conditions. Some other similar studies have also been reported by other researchers on power tillers (Dewangan and Tiwari, 2009, Salokhe *et al.*, 1995, Tiwari *et al.*, 2004) [2, 7, 11]. The objective of this study is to evaluate the ergonomic characteristics of power tiller by conventional method of puddling.

2. Materials and Methods

The experiment was conducted in University of Agricultural Sciences Raichur and Farmers' field near to Raichur for ergonomic evaluation of power tiller during 2020-21 year. The parameters are selected for the ergonomic evaluation of power tiller with different forward speeds, rotary speeds and type of blades like 1.8, 2.1 and 2.4 km h^{-1}, 220, 260 and 300 rpm and C and J type of blades, respectively.

2.1 Machine parameters

The machine parameters like vibrations and noise were considered for the development of automation system for power tiller. The conventional method of puddling operation was studied in relation to ergonomic characteristics which are presented below. The noise and vibrations were measured or recorded in field conditions as explained in below.

A. Conventional method of puddling

In India, farmers mainly use tractor mounted implements for puddling operations like tractor attached with planker and cultivator, tractor attached pulverizing roller, paddy harrow, pedal type puddler, double cage wheel attached with tractor, single cage wheel attached with tractor, tractor with rotavator are used to churn the soil and burry or mix the standing weeds into the soil layer. This type of operation is very costlier for farmers compared to power tiller operated rotavator or rotary unit for puddling. The conventional method of puddling was done in farmer's field and is shown in plate 1. The use of power tillers in Indian agriculture is a major source of power in wetland cultivation, hill agriculture small farm cultivation, horticultural operation and forestry. Now a days, power tiller operated matching implements having major constraints which are not giving much importance in popularization of technology (Kumar *et al.*, 2021) [6]. Variables selected for performance evaluation of conventional method of puddling are shown in Table 1.

Plate 1: Conventional method of puddling by tractor attached half cage wheel with rotavator

Table 1: Variables selected for performance evaluation of conventional method of puddling

Sl. No.	Parameters	Levels
Independent variables		
1	Forward speed, km h^{-1}	1.8, 2.1, 2.4
2	Rotary speed, rpm	220, 260, 300
3	Types of blade	C, J
Dependent variables		
1	Hand transmitted vibration, m s^{-2}	
2	Noise at bystanders position, dB (A)	
3	Noise at operators ears position, dB (A)	

B. Mechanical vibration (hand transmitted vibration)

It is the amplitude of average mechanical vibration of assemblies and components measured at the power tiller which are functionally important from operators' comfort and durability point of view. It was measured with the help of suitable vibration measuring device (vibration meter). The measurement of machine vibration during tillage was aimed to determine the vibration level of the power tiller with the influence of implement during field operations as well as the effect of terrain in order to understand the amount of vibration transmitted to the body by comparing with the hand transmitted and whole body vibration. The measurements were taken in puddling fields using rotary unit. The hand transmitted vibration was measured by placing on the handle bar and handle for power tiller. The vibration from the handle of the power tiller is transmitted to the hand and arm of the operator through at handle-grip level as per the guide lines issued in ISO 5349 (1986) [5]. The test was carried out at selected levels of forward speed for the power tillers. Each trail was repeated for three times with an acquisition period of 30 sec and the peak value arrived from the spectrum was averaged for each selected levels of forward speed (Bini Sam, 2002) [1]. Measurement of hand transmitted vibration is shown in Plate 2.

Plate 2: Vibration measurements at handle of power tiller during field operation

C. Noise
The sound level meter was used for the noise measurement in decibel dB (A). The test site is an open space of radius not less than 50 m and free from any obstacle like building rocks *etc.* The test was conducted preferably in undisturbed area so that an external force does not affect the results and the following test was conducted noise at bystanders' position and atoperators ear level (Bini Sam, 2002) [1].

i. Noise at by standers position
The noise at bystanders' positions was measured by using portable HTC sound level meter for measurement of noise. The procedure was followed according to IS: 12180-1987.The person was standing at the headland with sound level meter at 1.2 m above the ground level and a distance of 7.5 m from the axis of forward movement of the vehicle. Measurement was carried out on each side of the vehicle. Measurements were carried out at selected levels of forward speed and rotary speeds of power tiller during the puddling operation. Each trail was repeated for three times with an acquisition period of 30 sec and the peak value arrived from the spectrum was averaged for each selected levels of forward speed. The noise measurement at bystanders position is shown in Plate 3.

Plate 3: Noise measurements at by standers position of power tiller

ii. Noise at operators ears position
The noise at operator's ear level was measured by using portable HTC sound level meter for measurement of noise Type SL-1350 (Plate 4) with 12.5 mm microphone pre-amplifier (B&K, Type 2669).The microphone enables one-third octave centre frequency measurements between 20 Hz and 6.3 kHz. The noise signals were pre-amplified and recorded by HTC sound level meter and then analysed in using a weighting filter to simulate the response of the ear to noise. The wind velocity at microphone height should not exceeded 3 m s^{-1} and care was taken to ensure that wind effect does not distort the results. The level of background noise was 10 dB below the level measured during the test and there was no obstacle likely to reflect the significant sound, such as building, solid fence, tree or other vehicle. The power tiller was put in proper test condition before conducting the experiments, that is, in full working order with full fuel tank and radiator.

Plate 4: Noise measurements at operators ears position

For walking type power tiller, the microphone axis was vertical and its diaphragm was 250 mm ± 20 mm to the left side of the operator's head and facing forward. The side of the head chosen for positioning the microphone was the one that encountered the higher sound pressure level. Measurements were carried out at selected levels of forward speed and rotary speed of power tiller during the puddling operation. The test was carried out for power tiller for puddling operation. Each trial was repeated for three times with an acquisition period of 30 sec and the peak value arrived from the spectrum was averaged for each selected levels of forward speed for all operations (Bini Sam, 2002) [1].

3. Results and Discussions
i. Effect of forward speed, rotary speed and type of blade on hand transmitted vibration
The results pertaining to the effect of operational parameters *viz.,* forward speed, rotary speed and type of blade on hand transmitted vibration of power tiller are presented in Table 2 and discussed below.

A maximum hand transmitted vibration of power tiller 3.24 m s^{-2} was recorded at 300 rpm of rotary speed for C type blade, while it was minimum of 2.10 m s^{-2} at 220 rpm of rotary speed for J type blade. A maximum hand transmitted vibration of power tiller 4.60 m s^{-2} was recorded at 300 rpm of rotary speed for C type blade, while it was minimum (3.05 m s^{-2}) at 220 rpm of rotary speed for J type blade. A maximum hand transmitted vibration of power tiller 5.60 m s^{-2} was recorded at 300 rpm of rotary speed for C type blade, while it was minimum (3.80 m s^{-2}) at 220 rpm of rotary speed for J type blade.

It was observed that as the forward speed increased, the hand transmitted vibration also increased for all rotary speed. This might be suggestive of the fact that, the increase in engine speeds which contributes the major excitation of the HTV of the walking tractor because the handle of the power tiller acts like a cantilever beam. It was subjected to forced as well as free vibrations. The hand transmitted vibration of the power tiller increased as the forward increased, because it reduces the exposure time. The magnitude of hand transmitted vibration was highest in the frequency range of 6.3-16 Hz for all levels of selected speeds. The results confirmed that human hand-arm system was most sensitive in the frequency range of 6.3-16 Hz (ISO 5349-1986) [5] (Bini Sam 2002) [1]. The J type blade gave the highest hand transmitted vibration compare to C type blade, because it cuts the soil and mix thoroughly in the water.

Table 2: Effect of forward speed, rotary speed and type of blade on hand transmitted vibration

Sl. No.	Forward speed, km h^{-1}	Rotary speed, rpm	Hand transmitted vibration (m s^{-2})	
			C type blade	J type blade
1	1.8	220	2.56	2.10
		260	2.80	2.45
		300	3.24	2.80
2	2.1	220	3.10	3.05
		260	3.85	3.60
		300	4.60	4.20
3	2.4	220	3.80	3.70
		260	4.65	4.46
		300	5.60	5.12

ii. Effect of forward speed, rotary speed and type of blade on noise at bystanders position

The results pertaining to the effect of operational parameters *viz.*, forward speed and rotary speed on noise at by standers position are presented in Table 3 and discussed below.

A maximum noise at bystanders position of power tiller 84.50 dB(A) was recorded at 300 rpm of rotary speed for C type of blade, while it was minimum (80.50 dB(A)) at 220 rpm of rotary speed J type of blade. A maximum noise at bystanders position of power tiller 86.90 dB(A) was recorded at 300 rpm of rotary speed for C type of blade, while it was minimum (81.80 dB (A)) at 220 rpm of rotary speed for J type of blade. A maximum noise at bystanders position of power tiller 88.40 dB (A) was recorded at 300 rpm of rotary speed for C type blade, while it was minimum (82.60 dB (A)) at 220 rpm of rotary speed for J type blade.

It was observed that, as the forward speed increased the noise at bystanders position of power tiller also increased for all rotary speeds. This was due to the facts that as rotary speed increased as the forward speed increased and the engine has to produce more horsepower to overcome load increment and thus increased the noise. From figure it was observed the noise at bystanders positions during puddling operation was more than the allowable level (85 dB(A)) which was given by Occupational Safety and Health Administration (OSHA), national institute for occupational safety and health (NIOSH) and International Organization for Standardization. The forward speed, rotary speed and type of blades directly affect on the noise at bystanders positions. The forward speed increased noise at by standers positions was increased for both blades. This is due to the fact that forward speed increased means machine move faster which resulted in more noise produced. As the rotary speed increased noise at bystanders position was increased, because rotary unit moves faster soil-metal contact was increased during the puddling operation which creates lot of noise to the operator. These findings were agreed with (Bini Sam 2002) [1]. C type blade gave maximum noise compare to J type blade, because J blade gave better performance of puddling, means better churning that gives better results by more fine texture soil on top of the surface, which resulted to less noise produced at bystanders positions.

iii. Effect of forward speed and rotary speed on noise at operator ears position

The results pertaining to the effect of operational parameters *viz.*, forward speed and rotary speed on noise at operator ears position are presented in Table 4 and discussed below.

A maximum operator ears position of power tiller 87.70 dB(A) was recorded at 300 rpm of rotary speed for C type of blade, while it was minimum (82.50 dB (A)) at 220 rpm of rotary speed for J type of blade. A maximum noise at operator ears position of power tiller 90.80 dB (A) was recorded at 300 rpm of rotary speed for C type of blade, while it was minimum (87.20 dB (A)) at 220 rpm of rotary speed for J type of blade A maximum noise at operator ears position of 97.00 dB(A)was recorded at 300 rpm of rotary speed for C type of blade, while it was minimum (91.30 dB (A)) at 220 rpm of rotary speed for J type of blade.

It was observed that, as the forward speed increased the noise at operators ears position also increased for all rotary speeds. This is due to the fact that noise produced by the tractor increased as engine speed increased. The noise at a power tiller operators' ears level during puddling operation with rotary tiller was higher than the permissible level of 85 dB (A) which was given by Occupational Safety and Health Administration (OSHA), national institute for occupational safety and health (NIOSH) and International Organization for Standardization. As the forward speed and rotary speed increased, noise also increased it leads to create movement disorders, damage to various body organs including the ear, spine and gastrointestinal disorders, and neurological diseases. Development of automation system for power tiller is the alternative way for puddling operation in paddy cultivation to reduce the noise and vibration from the power tiller during puddling operation. These findings are agreed with Gonçalves *et al.* (2019) [3] and Sehsah *et al.* (2010) [9].

Table 3: Effect of forward speed, rotary speed and type of blade on noise at by standers position

Sl. No.	Forward speed, km h^{-1}	Rotary speed, rpm	Noise at bystander position dB(A)	
			C type blade	J type blade
1	1.8	220	81.50	80.50
		260	82.20	81.20
		300	84.50	82.50
2	2.1	220	83.80	81.80
		260	85.40	82.40
		300	86.90	83.90
3	2.4	220	85.10	82.60
		260	86.90	84.00
		300	88.40	85.40

Table 4: Effect of forward speed, rotary speed and type of blade on noise at operators ears position

Sl. No.	Forward speed, km h^{-1}	Rotary speed, rpm	Noise at operators ear positions dB(A)	
			C type blade	J type blade
1	1.8	220	82.50	81.00
		260	85.30	82.60
		300	87.70	84.30
2	2.1	220	87.20	85.50
		260	88.60	87.00
		300	90.80	89.50
3	2.4	220	91.30	90.20
		260	93.40	93.40
		300	97.00	95.00

4. Conclusion

The performance evaluation was conducted at three forward speeds (1.8, 2.1 and 2.4 km h^{-1}) and rotary speeds (220, 260 and 300 rpm) with two blade types (C and J-type) for conventional method of puddling and automation system of power tiller for puddling operation. Statistical analysis was carried out by using the Stat-Ease version10 of Design-Expert software to study the effect of operational parameters. The noise at by standers position increased as the both forward speed and rotary speed increased. The maximum noise of 88.40 dB (A) was recorded at bystanders position at 2.4 km h^{-1} for 300 rpm with C type of blade and it was minimum (81.50 dB (A)) at 1.8 km h^{-1} for 220 rpm with J type of blade. The noise at operators ears position increased as the both forward speeds and rotary speeds increased. The noise at operators ears position was maximum (97.00 dB (A)) at 2.4 km h^{-1} for 300 rpm with C type of blade and it was minimum of 82.50 dB (A) at forward speed of 1.8 km h^{-1} for 220 rpm with J type of blade.

5. References

1. Bini Sam. Investigation on ergonomics of power tiller operation as influenced by vibration, noise and physiological stress, Ph.D. Thesis from TNAU, Coimbatore; c2002.
2. Dewangan KN, Tiwari VK. Characteristics of hand transmitted vibration of a hand tractor used in three operational modes. International Journal of Indian Ergonomics. 2009;39:239-245.
3. Goncalves LM, Ferraz GAS, Oliveira MS, Barbosa BD S, Silva CJ, Ferraz FPP. Characterization of noise emitted by a power tiller through geo statistics. Revista Brasileira Engenharia Agricola Ambiental. 2019;3(3):223-228.
4. IS 12180. Method for noise measurement of agricultural tractors. Bureau of Indian Standards, New Delhi; c1987. p. 3-4.
5. ISO 5349. Acoustics-Tractors and machinery for agriculture and forestry- Measurement of noise at operator's position-Survey method, Geneva; c1986. p. 1-10.
6. Kumar S, Mahapatra M, Behera D, Pradhan PL, Swain SK, Kamendra1, *et al*. A comprehensive review on versatility of power tiller. AMA. 2021;51(3):1483-1500.
7. Salokhe VM, Majumder B, Islam MS. Vibration characteristics of a power tiller. Journal of Terra mechanics. 1995;32:181-196.
8. Sam B, Kathirvel K. Vibration characteristics of walking and riding type power tillers. Biosystem Engineering. 2006;95(4):517-528.
9. Sehsah EE, Helmy MA, Sorour HM. Noise test of two manufactured power tillers during transport on different local road conditions. International Journal of Agricultural Biology and Engineering. 2010;3(4):1-9.
10. Taghizadeh-Alisaraei A, TavakoliHashjin T, Ghobadian B, Nikbakht AM. Evaluation of vibration in power tiller on the asphalt surface, Proceedings of the International Agricultural Engineering Cutting edge technologies and innovations on sustainable resources for world food sufficiency, Canada; c2007. p. 13-19.
11. Tiwari VK, Dewangan KN, Subrata K. Operator's fatigue in field operation of hand tractors. Bio system Engineering. 2004;89:1-11.