Whole body, Arm-Hand Vibration and Performance Drivers Tractors during Conservation Tillage under different Velocity and Soils

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Abstract— *The Experiment was carried out to determine the level vibration transfer in three axes Horizontal X, Lateral Y and Vertical Z direction to seat driver tractor, Vector sum of vibration and Daily Vibration Exposure (8 hours) in seat driver tractor, and vibration in steering wheel tractor, Heart Rate, Systolic and Diastolic blood pressure and temperature were measure to all Drivers before and after used Chisel plow in operation tillage. Statistical analysis system was used, Split-Split Plot Design under Randomized Complete Block Design, Three factors were used in this experiment included Two types of Soil Moist and Dry soil which represented main plot, Three Velocity Tractor was second factor included 1.6,3.5 and 5.4 km/hr and Three Drivers Tractor (D1, D2 and D3) was third factor. Result show higher levels Vibration in all direction in seat and steering wheel tractor when tillage dry soil and used high velocity tractor, heart rate increasing after operation tillage but no change in blood pressure and slight increasing (but still normal) in temperature.*

Keywords— Conservation Tillage, Chisel Plow, Soil, Vibration, Performance Drivers, Velocity Tractor.

I. INTRODUCTION

Random vibration transfer to tractor agricultural from soil field to Tiers then passing chasse to seat and steering wheel, The implement amounted behind the tractor such as Chisel plow when tilled transfer vibration to the tractor, So the driver tractor effected and attach these vibration, Add on Engine vibration tractor. The drivers of agricultural tractors are exposed two types of vibration Whole Body Vibrations (WBV) via the seat or via the floor and feet, and Hand Arm Vibration (HAV) (Hamid et al 2011, Issever 2003, Goglia 2006), which my by extremely sever depending upon such factors as the attached farm equipment, design, purpose, speeds of travel, condition of the field as soil dry or moisture and kind of Tiers and Pressure, the rpm of the engine, the type of seat …etc. These vibration are extremely complex and varied ,with multi- axes translational as longitudinal, lateral, vertical and rotational yaw, roll and pitch vibration inputs to different parts of the body (Hamid 2011). Vibration in tractors with low frequency is very dangerous on the drivers because the natural frequency on human body is low too, therefore may be Resonance happened (Hamid 2012,Hostens and Ramon 2003,Niranjan et al 1995). The impact between the tiers tractor and soil is effected by kind tiers, moist or soft and dry soil, texture, kind soil and topography field, velocity tractor, So the vibration transfer is variable. Increasing velocity of tractor when conducted operation tillage result to increasing vibration levels in deferent direction (Hamid 2011, Iman 2013). Szczepaniak 2013Found during the field test of the agricultural unit, that the whole body vibration is about 3 times higher, in vertical direction, when working at a speed of 4.16 ms-1 than for the speed of 1.39 ms-1. As previously stated, it is widely recognized that agricultural tractor operators are exposed to high levels of whole-body vibration (WBV) during typical farm operations. Kumar et al (2001) were measured the vibrations (root mean square rms) on different sizes of tractors under varying terrain conditions found The values were compared with ISO 2631-1, 1985 and 1997 standards exceed the 8 h exposure limit in one-third-octave frequency band procedure of ISO 2631-1 (1985) on both farm and non-farm terrains. American Conference of Governmental Hygienists (ACGIH)(2007) was limited exposure limits Maximum hand arm vibration from 4-8 hours is 4 m/sec², while Santia 2014 mention 2.5 m/sec² for working day 8 hours. ISO 2621–1(1997) recommended the vibration exposure value were 0.63 m/sec² for 4 hour exposure duration, 0.5 m/sec² for 8 hour exposure duration and 3.5 to 5.8 m/sec² considered caution zone. Several studies conducted by (Milosevic 1997) on drivers and heavy vehicles revealed significant changes in body temperature ,diastolic blood pressure and an increase in accommodation visual reaction time after prolonged driving. Hamid 2012 Found in experiment field vibration tractor increasing heart rate in 20 drivers tractor after operation tillage but no change in diastolic and

systolic blood pressure. The aim of these experiment is measuring whole body and arm-hand vibration ,Vector sum of vibration, Daily Vibration Exposure (8 hours) drivers tractor, Systolic, Diastolic, Heart Rate and Temperature drivers during conservation tillage in moist and dry soil under different velocity tractor.

Material and Methods

1-1 Field

Field experiment was conducted in Baghdad-Iraq. The field was not agriculture, and divided according to experimental design, Two part Soil, Moist soil was 16-19 % when soil tilled and Dry soil. Soil texture was silt clay loam (455, 435 and 110 g.kg-1 respectively). Field was 31.7 m above sea level and the weather temperature was measured 24 Cº and humidity was 57 %. Depth tillage was 25 cm.

1-2 Experimental Design

Split-Split Plot Design under Randomized Complete Block Design with Three replication using least significant design (LSD) 5 % was used to compare the mean of treatments. Statistical analysis system used (SAS 2010 and ALsahooki 1991). Three factors were used in this experiment included Two types of Soil included Moist and Dry soil which represented main plot, Three Velocity Tractor was second factor included 1.6,3.5 and 5.4 km/hr and Three Drivers Tractor (D1, D2 and D3) was third factor. Experiment included 18 treatments with three replication for each treatment (2×3×3×3= 54 Treatments).

1-3 Drivers Tractor

Three Drivers (subjects) Tractor, were take the driving experience of operator on tractor, all teetotalers, not consuming psychotropic drugs and enjoying body and sound health were selected for the present study, all drivers no smoking and no alcohol. Choosing the drivers was very care and all them were normal Body Mass Index (BMI) is a measure of your weight relative to your height, It gives an approximation of total body fat- and that's what increases the risk of diseases that are related to being overweight (National Institutes of Health 1998) (Table 1). BMI was obtained by measuring weight in kilograms and height in meters then the following equation was used (Dennis 2005).

$$BMI = Weight/(Height)^2 \qquad (1)$$

When result Under weight < 18.5, Normal 18.5 – 24.9, Over weight 25.0 – 29.9, Obesity > 30 over that, And Obesity divided to: Class I= 30.0 – 34.9, Class II = 35.5 – 39.9, Class III (Extreme) > 40.0 .

Table 1. Characteristics of the drivers according to Body Mass Index (BMI).

Drivers	Age (yr)	Height (m)*	Weight (kg)**	BMI	State
D1	28	1.69	63	22.0	Normal
D2	28	1.72	69	23.3	Normal
D3	28	1.78	78	24.6	Normal

*** Measuring were by Electronic Meter with Accuracy 1% of reading height and weight drivers.**

**** Weight is measured with wears but no shoes.**

The anthropometric data taken as Height in mm, weight in kg. Hand length in mm (hand length is upper most shoulder to the tip of middle finger), Foot length in mm, Eye height (seating) in mm, Body girth (at seating) in mm (see fig.1) and (Table 2).

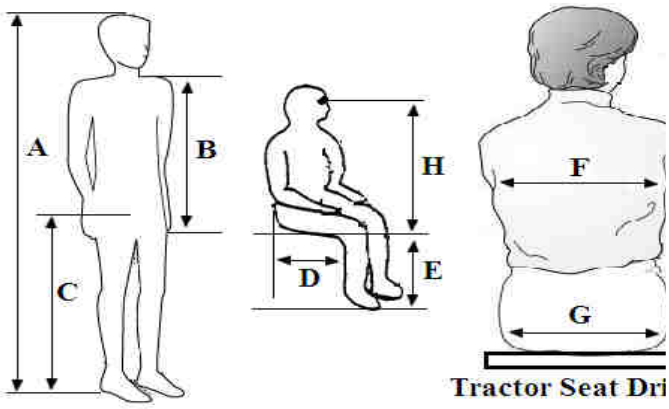

Fig.1 Anthropometric dimensions for tractor seat design according to NASA Anthropometric Source Book (NASA,1978): (A) Height, or Stature (B) Hand length, (C) Functional leg length (D) Buttock popliteal length, (E) Popliteal height, (F) Interscye breadth. (G) Hip breadth sitting, (H) Eye height sitting.

Table 2. Anthropometry Measurement of Drivers Tractor in these experiment.

Drivers Tractor	Height A(mm)	Hand Length B (mm)	Functional leg length C (mm)	Buttock popliteal Length D (mm)	Popliteal Height E (mm)	Interscye Breadth F(mm)	Hipbreadt Sitting G mm	Eye Height Seating H (mm)
D1	1690	730	900	450	470	350	350	730
D2	1720	750	930	470	500	360	380	740
D3	1780	770	960	500	520	380	430	770

1-4 Agriculture Tractor and Chisel plow

UZEL 290 Tractor and Chisel plow were used in these experiment, The technical characters of the Uzel tractor and chisel Plows are listed in Table 3. Chisel plow

mounted behind Tractor and adjusted on depth tillage 20 cm By put two Piece wood (thickness 20 cm) each of them under rear tire tractor then attach and tying the chisel plow with three points hydraulic tractor. Tractor worked with full fuel tank and radiator and tires were standard size for the tractor, as specified by the manufacturer. Three speeds tractor were chose carefully 1.6, 3.5 and 5.4 km/hr by limited point start treatment length 40 m and must leftover 10 m at least before this 40 m to give the speed ground tractor stability in movement and operation tillage and determined time in second by stopwatch to cross the tractor these distance (calculated the time tillage for 40 m only), then calculated by the following equation:

$$S = \left(\frac{D}{T}\right) \times 3.6 \qquad (2)$$

When S was speed measure in km / hr , D was distance treatment line tillage limited equal 40 m, T was time to cross tractor distance 40 m in sec, 3.6 was factor conversion.

Table 3. Technical characters Uzel 290 tractor and Chisel plow.

Characters Usel 290 tractor	
Power drive	2- wheel
Type engine	Perkins 4-stroke diesel with direct fuel injection
Cylinders no	4
Engine power (H.P)	92
Cooling system	liquid force feed with thermostat
Maximal r.p.m	2200
Suspension Seat	Spring
Tires front size	7-50 R16
Tires rear size	18-4 R30
Fuel tank capacity (Liter)	70
Characteristics of the Chisel plow.	
No. of Tines	9
Max. Working Width (mm)	2160
Plough depth (mm)	350
Made	Turkey

1-5 Vibration Meter and Calibrated

Lutron vibration meter (Lutron VB – 8201HA) serial number (Q405638) made in Taiwan, it was used for measuring vibration levels (Fig.2), was calibrated prior to measurement for all directions with another vibration meter and the results were the same in both of them for all readers. Professional vibration meter measurement Velocity, Acceleration RMS value and Peak value, supply with vibration sensor and magnetic base, full set, Data hold button to freeze the desired reading with memory function to record data reading with recall and super large LCD display (61×34 mm), vibration meter weight 274 g, dimension 185×78×38 mm and vibration sensor probe (Round 16 mm Dia×29 mm).

Fig.2 Vibration Meter and Sensor

5-1 Vibration Measurement

Driver seat tractor is portion of the machine provided for the purpose of supporting the buttocks and back of the seated operator, including any suspension system and other mechanisms provided (for example, for adjusting the seat position). The Drivers of agricultural tractors are often exposed to a low frequency vibration environment, partly caused by the movement of the tractor over uneven ground and the tasks carried out. The seat constitutes the last stage of suspension before the driver tractor. The most important vibration in tractors accrue to driver is Whole-body vibration (WBV) is vibration transmitted to the body as a whole through the buttocks of a seated driver tractor with many axes translational as longitudinal, lateral, vertical and rotational as yaw, roll and pitch (Fig.3), and Hand-arm vibration (HAV) is vibration transmitted into hands and arms when driver grip steering wheel tractors (fig.4).

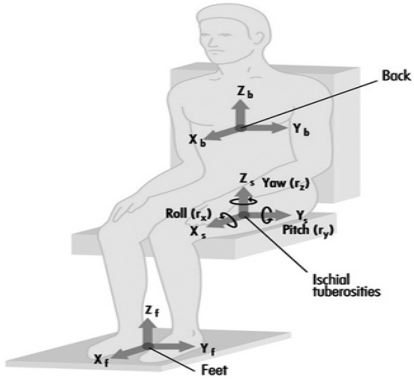

Fig.3 Translational and rotational vibration in seat driver tractor

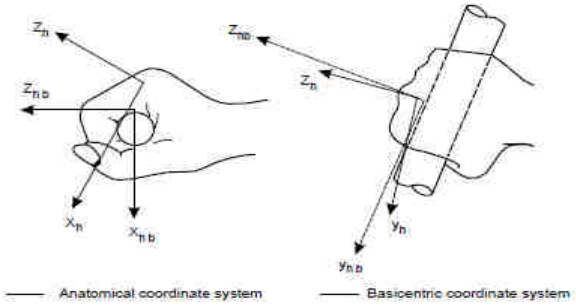

Fig.4 Coordinate system for the hand (according to ISO 5349).

Root mean square (RMS) is the square root of the arithmetic mean of instantaneous values (amplitude or acceleration) square . Root mean square acceleration gives the total energy across the entire range. The weighted RMS acceleration is expressed in m/sec² and is calculated by the following equation :

$$a_w = \left[\frac{1}{T}\int_0^T a_w^2\ (t)dt\right]^{1/2} \qquad (3)$$

Where $a_w(t)$ is the weighted acceleration as a function of time in m/sec² and T is the duration of measurement in seconds.

According to ISO 2631:1997, the weighted value of acceleration aw can be used to evaluate human riding comfort of man- agricultural combination system.Vector sum of weighted values of acceleration in seat driver tractor can be obtained by following equation(ISO 2631-1,1997) which used by researchers (Hamid 2013, Szczepaniak 2013 and Marsili 2002):

$$ahv = \left[k_x^2\ a_{wx}^2 + k_y^2\ a_{wy}^2 + k_z^2\ a_{wz}^2\right]^{1/2} \qquad (4)$$

Where *ahv* the vector-sum vibration magnitude (m/sec²)

a_{wx}, a_{wy} and a_{wz} are the weighted RMS acceleration in X, Y and Z direction and k_x, k_y and k_z are the orthogonal (measurement) axis multiplying factor specified by ISO 2631-1:1997 for seated persons. For the evaluation of the effect of vibration on health the values for multiplying factors given by ISO 2631 – 1 (1997) are $k_x = 1.4$, $k_y = 1.4$ and $k_z = 1$

The daily vibration exposure shall be expressed in terms of the (8 hours) energy equivalent frequency-weighted vibration total value as:

$$A\ (8) = a_{hv}\sqrt{\frac{T}{To}} \qquad (5)$$

Where *T* is duration of exposure to the vibration magnitude *ahv* in these experiment *T* was 6.5 hr (23400 sec), and *To* is reference duration of 8 hours (28,800 seconds).

ISO 2631-1:1997 suggests approximate indications of public perception to a range of overall total RMS vibration emission values (see Table 4)

Table 4. Likely perception of discomfort resulting from WBV (as suggested by ISO 2631-1:1997).

Vibration total value (m/sec²)	**Perceived comfort level**
Less than 0.315	Not uncomfortable
0.315 – 0.63	A little uncomfortable
0.5 – 1.0	Fairly uncomfortable
0.8 – 1.6	Uncomfortable
1.25 – 2.5	Very uncomfortable
Greater than 2.0	Extremely uncomfortable

In these experiment measured vibration in seat tractor by put Sensor vibration meter in three location to measure vibration in three dimensions Horizontal X, Lateral Y and Vertical Z (see fig. 5), Then we measure vibration in steering wheel tractor in three dimension Horizontal X, Lateral Y and Vertical Z by tying Adaptor and clip in steering wheel tractor and put Sensor vibration meter in adaptor (see fig. 6), We Measuring level vibration for all treatments wit three replication for each treatment.

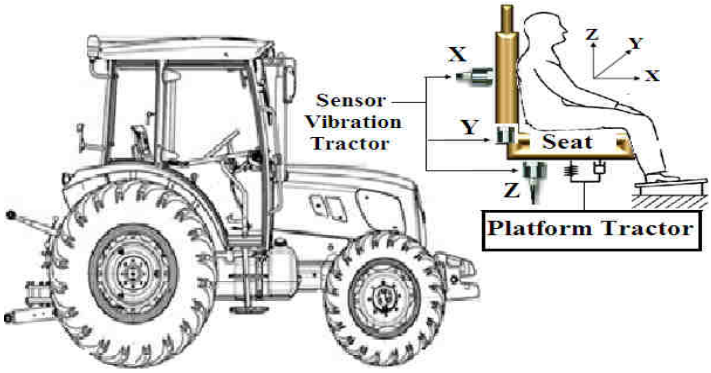

Fig.5 Accelerometer (Sensor) Location in Seat Driver Tractor to measuring Horizontal X, Lateral Y and Vertical Z.

Fig. 6 Accelerometer (Sensor) locations on steering wheel during measurement.

1-6 Blood Pressure, Heart Rate and Temperature Body Drivers tractor

When the Human (Drivers) heart pumps blood through the blood vessels, the blood pushes against the walls of drivers blood vessels, This creates blood pressure. Human body needs blood pressure to move the blood throughout

human body, so every part of the body can get the oxygen it needs. Human blood pressure is recorded as two numbers. The systolic blood pressure (the "upper" number) tells how much pressure blood is exerting against human artery walls while the heart is pumping blood, The diastolic blood pressure (the "lower" number) tells how much pressure blood is exerting against your artery walls while the heart is resting between beats. Blood pressure is measured in units of millimeters of mercury, or mm Hg, For example, a blood pressure reading might be 120/80 mm Hg (American Heart Association2014). A healthy blood pressure is under 120/80 mm Hg (Table 5). In some studies show significant change in Blood Pressure and Heart Rate during work and stress and mental stress (Hamid 2012 ,Fumio et al 2002 and Theorell et al 1985). Heart Rate had been used as a physiological measure of workload during driving (Lal 2001). The pulse can be defined as the frequency at which the heart beats. Pulse rate, in human beings is a vital sign of indication of a person's health. Other vital signs include body temperature, respiration rate and blood pressure, Pulse rate does not remain constant throughout the body even in a healthy driver tractor, It deviates according to the activities of an driver tractor. Normal pulse rate for healthy adults approximately 75 beats per minute, so the cardiac cycle length is approximately 0.8 seconds (National Institutes of Health 2003). Porges 1998 suggested that heart rate was the most sensitive cardiovascular index of the work load and the fatigue associated with driving, Thus heart rate has been used as a physiological indicator for measuring the performance of the operator in the present work. Body Drivers tractor temperature is a complex, non-linear variable that is subject to many sources of internal and external variation. A widely accepted medical concept is that a normal body temperature for a healthy adult is approximately 98.6° F / 37.0° C.

In this Experimental Field Rossmax Blood Pressure Monitor Model LC 150 had been used, made in USA Cincinnati, Ohio designed in accordance with international standard ISO 9001 and CE 0366 to measure Systolic and Diastolic Pressure and Heart Rate. We must keep correct measuring posture by place your elbow the table so that the cuff is the same level as your heart (see Fig.7). Rossmax Blood Pressure Monitor Calibrated in hospital in Baghdad with A sphygmomanometer (is an instrument used to obtain blood pressure readings by the auscultator method) for many people by measure both instruments and the results were same in all measures.

Table 5. Healthy and unhealthy blood pressure ranges (American Heart Association 2014).

Blood Pressure Category	**Systolic mm Hg*(Upper)**		**Diastolic mm Hg (Lower)**
Normal	Less than 120	And	Less than 80 **Good for human**
Prehypertension	120 - 139	Or	80 - 89
High Blood Pressure (Hypertension) Stage 1	140 - 159	Or	90 - 99
High Blood Pressure (Hypertension) Stage 2	160 or Higher	Or	100 or Higher
Hypertensive Crisis (Emergency care needed)	Higher than 180	Or	Higher than 110

*** Millimeters of mercury.**

Fig. 7. Rossmax Blood Pressure Monitor and method measuring for Driver Tractor.

II. RESULT AND DISCUSSION

1-2 Vibration in Seat Tractor

Tables 6, 7 and 8 effects Soil Types, Velocity tractor and Drivers and interaction on Vibration Longitudinal X , Literal Y and Vertical Z in Seat tractor. Results show significant effects to the soil types in vibration seat tractor in three axes X, Y and Z. Moist soil recorded lower values were 4.08, 1.87 and 2.40 m/sec² L,Y and Z as respectively, while Dry soil recorded higher values 5.92, 3.60 and 4.69 m/sec² as X,Y and Z, That may be because the different in Stiffness and resistance between moist and dry soil against penetration chisel plow. Result show significant effects to velocity tractor in vibration seat tractor in three axes X, Y and Z, Velocity tractor 1.6 km/hr recorded lower values was 3.17, 1.51 and 2.17 m/sec² as X,Y and Z, While velocity 5.4 recorded higher values was 7.06,4.13 and 5.11 m/sec² as X,Y and Z and that because increasing vibration with increasing velocity tractor (see Fig.8) and these result in the same line with (Szczepaniak 2013 and Hamid 2011). Result show significant effects to Drivers in vibration seat tractor in

three axes X, Y and Z, Drivers D3 recorded lower values 4.87, 2.62 and 3.26 m/sec² as X,Y and Z, While D1 recorded higher values 5.15, 2.86 and 3.91 m/sec² as X,Y and Z, That may be because the different weight between drivers D1and D3.

Interaction between moist soil with velocity tractor 1.6 km/hr recorded lower vibration seat tractor in three axes X,Y and Z were 2.15,0.93 and 1.33 m/sec², while Interaction between Dry soil with 5.4 km/hr recorded higher vibration in three axes X,Y and Z were 7.76,5.33 and 6.63 m/sec².

Table 6. Effect Soil Types, Velocity Tractor and Drivers and interaction on Longitudinal (X) vibration in Seat tractor.

Longitudinal (X) vibration in Seat tractor					
Treatments		Interaction Soil Types, Velocity Tractor with Drivers			Interaction Soil type and Velocity Tractor
Soil Types	Velocity Tractor	Drivers			
		D1	D2	D3	
Moist	1.6	2.30	2.13	2.03	2.15
	3.5	3.86	3.73	3.63	3.74
	5.4	6.46	6.33	6.26	6.35
Dry	1.6	4.26	4.20	4.10	4.18
	3.5	6.00	5.80	5.70	5.83
	5.4	8.03	7.73	7.53	7.76
Drivers mean		5.15	4.98	4.87	
Soil Types		Interaction Soil Types with Drivers			Soil Types Mean
Moist		4.21	4.06	3.97	4.08
Dry		6.10	5.91	5.77	5.92
Velocity Tractor Km / hr		Interaction Velocity Tractor with Drivers			Velocity Tractor Mean
1.6		3.28	3.16	3.06	3.17
3.5		4.93	4.76	4.66	4.78
5.4		7.25	7.03	6.90	7.06

L.S.D 0.05
Soil Types : 0.0836 Velocity Tractor: 0.1024
Driver : 0.1024
Interaction Soil Types with Velocity Tractor: 0.1765
Interaction Soil Types with Drivers : 1.6527
Interaction Velocity Tractor with Drivers: 1.2309
Interaction Soil Types , Velocity Tractor with Drivers: 0.2507

Table 7. Effect Soil Types, Velocity Tractor and Drivers and interaction on Lateral (X) vibration in Seat tractor.

Vertical (Z) vibration in Seat tractor					
Treatments		Interaction Soil Types, Velocity Tractor with Driver Weight			Interaction Soil type and Velocity Tractor
Soil Types	Velocity Tractor	Drivers			
		D1	D2	D3	
Moist	1.6	1.46	1.33	1.20	1.33
	3.5	2.50	2.50	2.03	2.27
	5.4	4.06	3.53	3.16	3.58
Dry	1.6	3.43	3.00	2.63	3.02
	3.5	4.83	4.00	4.43	4.42
	5.4	7.16	6.63	6.10	6.63
Drivers mean		3.91	3.46	3.26	
Soil Types		Interaction Soil Types with Drivers			Soil Types Mean
Moist		82.67	2.48	2.13	2.40
Dry		5.14	4.54	4.38	4.69
Velocity Tractor Km / hr		Interaction Velocity Tractor with Drivers			Velocity Tractor Mean
1.6		2.45	2.16	1.91	2.17
3.5		3.66	3.15	3.23	3.35
5.4		5.61	5.08	4.63	5.11

L.S.D 0.05
Soil Types : 0.0776 Velocity Tractor : 0.0951
Drivers : 0.0951
Interaction Soil Types with Velocity Tractor : 0.344
Interaction Soil Types with Drivers : 1.2869
Interaction Velocity Tractor with Drivers: 1.554
Interaction Soil Types , Velocity Tractor with Drivers: 0.2329

Interaction between Moist soil with Driver D3 recorded lower vibration seat tractor in three axes X,Y and Z were 3.97, 1.74 and 2.13 m/sec², while Interaction between Dry soil with Driver D1 recorded higher vibration in three axes X,Y and Z were 6.10, 3.72 and 5.14 m/sec². Interaction between velocity tractor 1.6 km/hr with Driver D3 recorded lower vibration seat tractor in three axes X,Y and Z were 3.06, 1.40 and 1.91 m/sec², while Interaction between Dry soil with velocity 5.4 km/hr recorded higher vibration in three axes X,Y and Z were 7.25, 4.28 and 5.61 m/sec². Interaction among Moist soil with Velocity tractor 1.6 km/hr with Driver D3 recorded lower vibration seat tractor in three axes X,Y and Z were 2.06, 0.80 and 1.20 m/sec². Interaction among Dry soil with Velocity tractor 5.4 km/hr with Driver D1 recorded higher vibration seat tractor in three axes X,Y and Z were 6.0, 5.46 and 7.16 m/sec².

Table 8. Effect Soil Types, Velocity Tractor and Drivers and interaction on Vertical (X) vibration in Seat tractor.

Lateral (Y) vibration in Seat tractor					
Treatments		Interaction Soil Types, Velocity Tractor with Drivers			Interaction Soil type and Velocity Tractor
Soil Types	Velocity Tractor	Drivers			
		D1	D2	D3	
Moist	1.6	1.03	0.96	0.80	0.93
	3.5	1.86	1.73	1.63	1.74
	5.4	3.10	2.90	2.80	2.93
Dry	1.6	2.20	2.06	2.00	2.08
	3.5	3.50	3.40	3.30	3.40
	5.4	5.46	5.30	5.23	5.33
Drivers mean		2.86	2.72	2.62	
Soil Types		Interaction Soil Types with Drivers			Soil Types Mean
Moist		2.00	1.86	1.74	1.87
Dry		3.72	3.58	3.51	3.60
Velocity Tractor Km / hr		Interaction Velocity Tractor with Drivers			Velocity Tractor Mean
1.6		1.61	1.51	1.40	1.51
3.5		2.68	2.56	2.46	2.57
5.4		4.28	4.10	4.01	4.13
L.S.D 0.05					
Soil Types : 0.0493 **Velocity Tractor : 0.0604** **Drivers:0.0604**					
Interaction Soil Types with Velocity Tractor : 0.1242					
Interaction Soil Types with Drivers : 1.1405					
Interaction Velocity Tractor with Drivers : 1.1851					
Interaction Soil Types , Velocity Tractor with Drivers: 0.1479					

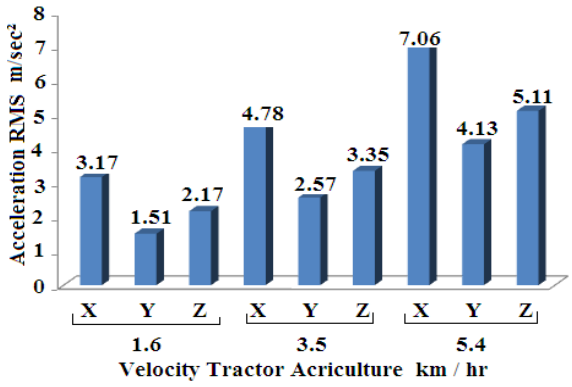

Fig.8 Increasing vibration in seat tractor (Longitudinal X, Lateral Y and Vertical) with increasing Velocity Tractor.

2-2 Vector Sum of vibration in seat driver tractor

Tables 9. Effects Soil Types, Velocity tractor and Drivers and interaction on Vector sum of vibration in Seat driver tractor. Results show significant effects to the soil types in Vector sum of vibration in seat driver tractor. Moist soil recorded lower values were 6.76 m/sec², while Dry soil recorded higher values 10.80 m/sec², That may be because the different in Stiffness and resistance between moist and dry soil against penetration chisel plow. Result show significant effects to velocity tractor in Vector sum of vibration in seat driver tractor, Velocity tractor 1.6 km/hr recorded lower values was 5.39 m/sec², While velocity 5.4 km/hr recorded higher values was 12.62 m/sec² because when increasing velocity tractor increasing vibration in all directions, and these result in the same line with (Szczepaniak 2013 and Hamid 2011). Result show significant effects to Drivers in Vector sum of vibration in seat driver tractor, Drivers D3 recorded lower values 14.21 m/sec², While driver D1 recorded higher values 15.37 m/sec², That may be because the different weight between drivers D1and D3. Interaction between moist soil with velocity tractor 1.6 km/hr recorded lower Vector sum of vibration in seat driver tractor was 3.56 m/sec², while Interaction between Dry soil with 5.4 km/hr recorded higher value was 14.76 m/sec². Interaction between Moist soil with Driver D3 recorded lower Vector sum of vibration in seat driver tractor was 6.47 m/sec², while Interaction between Dry soil with Driver D1 recorded higher value 11.26 m/sec². Interaction between velocity tractor 1.6 km/hr with Driver D3 recorded lower Vector sum of vibration in seat driver tractor 5.09 m/sec², while Interaction between Dry soil with velocity 5.4 km/hr recorded higher value was 13.10 m/sec². Interaction among Moist soil with Velocity tractor 1.6 km/hr with Driver D3 recorded lower Vector sum of vibration in seat driver tractor was 3.28 m/sec². Interaction among Dry soil with Velocity tractor 5.4 km/hr with Driver D1 recorded higher value 15.37 m/sec². Fig. 9 and 10 explain the interaction among moist and dry soil, velocity tractor and drivers on vector sum of vibration in Seat driver tractor, these vibration was highly during tillage dry soil compare with tillage moist soil and increasing with increasing velocity tractor on both types soil, Driver D3 recorded least values during tillage moist and dry soil in all velocity compare with drivers D1 and D2 that because D3 was more weight body from D1 and D2 so the seat driver tractor received least transfer vibration wit driver D3.

Tables 9. Effects Soil Types, Velocity tractor and Drivers and interaction on Vector sum of vibration in Seat driver tractor.

Vector Sum of vibration in seat driver tractor					
Treatments		Interaction Soil Types, Velocity Tractor with Drivers			Interaction Soil type and Velocity Tractor
Soil Types	Velocity Tractor	Driver Weight			
		D1	D2	D3	
Moist	1.6	3.82	3.60	3.28	3.56
	3.5	6.51	6.20	6.01	6.24
	5.4	10.83	10.49	10.11	10.48
Dry	1.6	7.54	7.20	6.90	7.21
	3.5	10.86	10.22	10.22	10.43
	5.4	15.37	14.70	14.21	14.76
Drivers mean		9.15	8.73	8.46	
Soil Types		Interaction Soil Types with Drivers			Soil Types Mean
Moist		7.05	6.76	6.47	6.76
Dry		11.26	10.70	10.44	10.80
Velocity Tractor Km / hr		Interaction Velocity Tractor with Drivers			Velocity Tractor Mean
1.6		5.68	5.40	5.09	5.39
3.5		8.68	8.21	8.12	8.34
5.4		13.10	12.59	12.16	12.62

L.S.D 0.05
Soil Types : 0.1177 **Velocity Tractor: 0.1441**
Drivers: 0.1441
Interaction Soil Types with Velocity Tractor: 0.3589
Interaction Soil Types with Drivers: 3.0609
Interaction Velocity Tractor with Drivers: 2.6536
Interaction Soil Types , Velocity Tractor with Drivers: 0.353

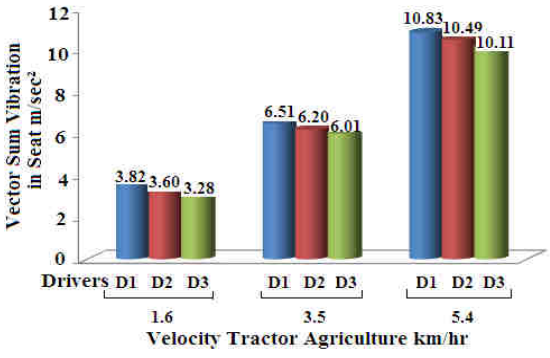

Fig.9 Interaction among moist soil, velocity tractor and drivers in Vector sum vibration in seat tractor.

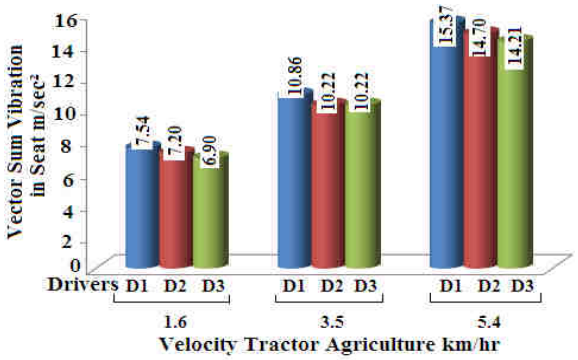

Fig.10 Interaction among Dry soil, velocity tractor and drivers in Vector sum vibration in seat tractor.

3-2 Daily Vibration Exposure (8 hours) in seat driver tractor

Tables 10. Effects Soil Types, Velocity tractor and Drivers and interaction on Daily Vibration Exposure (8 hours) in seat driver tractor, Results show significant effects to the soil types in Daily Vibration Exposure (8 hours) in seat driver tractor Moist soil recorded lower values were 6.07 m/sec², while Dry soil recorded higher value 9.77 m/sec².Result show significant effects to velocity tractor in Daily Vibration Exposure (8 hours) in seat driver tractor, Velocity tractor 1.6 km/hr recorded lower value was 4.92 m/sec², While velocity 5.4 km/hr recorded higher value was 11.35 m/sec² because when increasing velocity tractor increasing vibration in all directions. Result show significant effects to Drivers in Daily Vibration Exposure (8 hours) in seat driver tractor Vector, Drivers D3 recorded lower value was 7.59 m/sec², While driver D1 recorded higher values 8.31 m/sec², That may be because the different weight between drivers D1and D3. Interaction between moist soil with velocity tractor 1.6 km/hr recorded lower Daily Vibration Exposure (8 hours) in seat driver tractor was 3.20 m/sec², while Interaction between Dry soil with 5.4 km/hr recorded higher value was 13.28 m/sec². Interaction between Moist soil with Driver D3 recorded lower Daily Vibration Exposure (8 hours) in seat driver tractor was 5.79 m/sec², while Interaction between Dry soil with Driver D1 recorded higher value 10.27m/sec². Interaction between velocity tractor 1.6 km/hr with Driver D3 recorded lower Daily Vibration Exposure (8 hours) in seat driver tractor 4.58 m/sec², while Interaction between Dry soil with velocity 5.4 km/hr recorded higher value was 11.79 m/sec²(see fig.11). Interaction among Moist soil with Velocity tractor 1.6 km/hr with Driver D3 recorded lower Daily Vibration Exposure (8 hours) in seat driver tractor was 2.95 m/sec², while Interaction among Dry soil with Velocity tractor 5.4 km/hr with Driver D1 recorded higher value 13.83 m/sec².

Tables 10. Effects Soil Types, Velocity tractor and Drivers and interaction on Daily Vibration Exposure (8 hours) in seat driver tractor.

Daily Vibration Exposure (8 hours) in seat driver tractor.					
Treatments		Interaction Soil Types, Velocity Tractor with Drivers			Interaction Soil type and Velocity Tractor
Soil Types	Velocity Tractor	Driver Weight			
		D1	D2	D3	
Moist	1.6	3.43	3.23	2.95	3.20
	3.5	5.85	5.57	5.33	5.58
	5.4	9.74	9.43	9.10	9.47
Dry	1.6	7.23	6.48	6.21	6.64
	3.5	9.76	9.19	9.19	9.38
	5.4	13.83	13.22	12.78	13.28
Drivers mean		8.31	7.85	7.59	
Soil Types		Interaction Soil Types with Drivers			Soil Types Mean
Moist		6.34	6.08	5.79	6.07
Dry		10.27	9.63	9.39	9.77
Velocity Tractor Km / hr		Interaction Velocity Tractor with Drivers			Velocity Tractor Mean
1.6		5.33	4.85	4.54	4.92
3.5		7.81	7.38	7.26	7.48
5.4		11.79	11.33	10.94	11.35

L.S.D 0.05
Soil Types : 0.1212 Velocity Tractor: 0.1484 Drivers: 0.1484
Interaction Soil Types with Velocity Tractor: 0.3703
Interaction Soil Types with Drivers: 2.7265
Interaction Velocity Tractor with Drivers: 2.428
Interaction Soil Types , Velocity Tractor with Drivers: 0.3635

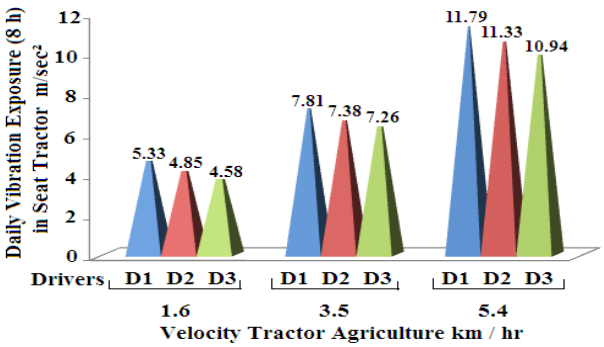

Fig.11 Interaction between velocity tractor and drivers on Daily vibration exposure (8 h) in seat tractor.

4-2 Vibration in Steering Wheel Tractor

Tables 11, 12 and 13 effects Soil Types, Velocity tractor and Drivers and interaction on Vibration Longitudinal X , Literal Y and Vertical Z in Steering Wheel Tractor. Results show significant effects to the soil types in vibration in steering wheel tractor in three axes X, Y and Z. Moist soil recorded lower values were 1.50, 1.07 and 2.08 m/sec² L,Y and Z as respectively, while Dry soil recorded higher values 2.56, 2.00 and 3.70 m/sec² as X,Y and Z directions. Result show significant effects to velocity tractor in vibration steering wheel tractor in three axes X, Y and Z, Velocity tractor 1.6 km/hr recorded lower values was 1.40, 1.02 and 1.93 m/sec² as X,Y and Z, While velocity 5.4 km/hr recorded higher values was 2.67, 2.10 and 3.91 m/sec² as X,Y and Z as respectively (see fig 12). Result show significant effects to Drivers in vibration steering wheel tractor in two axes X, Y, Drivers D3 recorded lower values 1.90, 1.47 m/sec² as X and Y, While D1 recorded higher values 2.13, 1.61 m/sec² as X and Y, Result show too, insignificant effect in vertical vibration Z in steering wheel. Interaction between moist soil with velocity tractor 1.6 km/hr recorded lower vibration steering wheel tractor in three axes X,Y and Z were 1.05, 0.65 and 1.50 m/sec², while Interaction between Dry soil with 5.4 km/hr recorded higher vibration in three axes X,Y and Z were 3.36, 2.66 and 5.01m/sec². Interaction between Moist soil with Driver D3 recorded lower vibration steering wheel tractor in three axes X,Y and Z were 1.33, 1.02 and 2.01 m/sec², while Interaction between Dry soil with Driver D1 recorded higher vibration in three axes X,Y and Z were 2.62, 2.08 and 3.74 m/sec². Interaction between velocity tractor 1.6 km/hr with Driver D3 recorded lower vibration steering wheel tractor in three axes X,Y and Z were 1.25, 0.95 and 1.98 m/sec², while Interaction between Dry soil with velocity 5.4 km/hr recorded higher vibration in three axes X,Y and Z were 2.80, 2.16 and 3.93 m/sec². Interaction among Moist soil with Velocity tractor 1.6 km/hr with Driver D3 recorded lower vibration steering wheel tractor in three axes X,Y and Z were 0.86, 0.60 and 1.43 m/sec². Interaction among Dry soil with Velocity tractor 5.4 km/hr with Driver D1 recorded higher vibration steering wheel tractor in three axes X,Y and Z were 3.43, 2.73 and 5.03 m/sec².

Tables 11. Effects Soil Types, Velocity tractor and Drivers and interaction on Vibration Longitudinal X in Steering Wheel Tractor.

Longitudinal Vibration X in Steering Wheel Tractor.					
Treatments		Interaction Soil Types, Velocity Tractor with Drivers			Interaction Soil type and Velocity Tractor
Soil Types	Velocity Tractor	Driver Weight			
		D1	D2	D3	
Moist	1.6	1.20	1.10	0.86	1.05
	3.5	1.56	1.53	1.33	1.47
	5.4	2.16	2.00	1.80	1.98
Dry	1.6	1.83	1.76	1.63	1.74
	3.5	2.60	2.63	2.53	2.58
	5.4	3.43	3.40	3.26	3.36
Drivers mean		2.13	2.07	1.90	
Soil Types		Interaction Soil Types with Drivers			Soil Types Mean
Moist		1.64	1.54	1.33	1.50
Dry		2.62	2.60	2.47	2.56
Velocity Tractor Km / hr		Interaction Velocity Tractor with Drivers			Velocity Tractor Mean
1.6		1.51	1.43	1.25	1.40
3.5		2.08	2.08	1.93	2.03
5.4		2.80	2.70	2.53	2.67
L.S.D 0.05					
Soil Types : 0.0931 Velocity Tractor: 0.1141					
Drivers: 0.1141					
Interaction Soil Types with Velocity Tractor: 0.1748					
Interaction Soil Types with Drivers: 0.5731					
Interaction Velocity Tractor with Drivers: 0.7378					
Interaction Soil Types , Velocity Tractor with Drivers: 0.2794					

Tables 12. Effects Soil Types, Velocity tractor and Drivers and interaction on Vibration Lateral Y in Steering Wheel Tractor.

Lateral Vibration (Y) in Steering Wheel Tractor.					
Treatments		Interaction Soil Types, Velocity Tractor with Drivers			Interaction Soil type and Velocity Tractor
Soil Types	Velocity Tractor	Driver Weight			
		D1	D2	D3	
Moist	1.6	0.73	0.63	0.60	0.65
	3.5	1.10	1.03	0.93	1.02
	5.4	1.60	1.50	1.53	1.54
Dry	1.6	1.50	1.40	1.30	1.40
	3.5	2.03	1.93	1.90	1.95
	5.4	2.73	2.70	2.56	2.66
Drivers mean		1.61	1.53	1.47	
Soil Types		Interaction Soil Types with Drivers			Soil Types Mean
Moist		1.14	1.05	1.02	1.07
Dry		2.08	2.01	1.92	2.00
Velocity Tractor Km / hr		Interaction Velocity Tractor with Driver			Velocity Tractor Mean
1.6		1.11	1.01	0.95	1.02
3.5		1.56	1.48	1.41	1.48
5.4		2.16	2.10	2.05	2.10
L.S.D 0.05					
Soil Types : 0.0805 Velocity Tractor: 0.0986 Drivers: 0.0986					
Interaction Soil Types with Velocity Tractor: 0.1359					
Interaction Soil Types with Drivers: 0.4764					
Interaction Velocity Tractor with Drivers: 0.636					
Interaction Soil Types , Velocity Tractor with Drivers: 0.2416					

Steering Wheel Tractor.

Tables 13. Effects Soil Types, Velocity tractor and Drivers and interaction on Vibration Vertical Z in Steering Wheel Tractor.

Vertical Vibration (Z) Steering Wheel Tractor.					
Treatments		Interaction Soil Types, Velocity Tractor with Drivers			Interaction Soil type and Velocity Tractor
Soil Types	Velocity Tractor	Drivers			
		D1	D2	D3	
Moist	1.6	1.56	1.50	1.43	1.50
	3.5	2.06	2.00	1.80	1.95
	5.4	2.83	2.80	2.80	2.81
Dry	1.6	2.56	2.30	2.53	2.46
	3.5	3.63	3.66	3.60	3.63
	5.4	5.03	5.06	4.93	5.01
Drivers mean		2.95	2.88	2.85	
Soil Types		Interaction Soil Types with Drives			Soil Types Mean
Moist		2.15	2.10	2.01	2.08
Dry		3.74	3.68	3.67	3.70
Velocity Tractor Km / hr		Interaction Velocity Tractor with Drivers			Velocity Tractor Mean
1.6		2.06	1.90	1.98	1.93
3.5		2.85	2.83	2.70	2.49
5.4		3.93	3.93	3.86	3.91

L.S.D 0.05
Soil Types : 0.1267 Velocity Tractor: 0.1552 Drivers: N.S
Interaction Soil Types with Velocity Tractor: 0.2023
Interaction Soil Types with Drivers: 0.8754
Interaction Velocity Tractor with Drivers: 1.1308
Interaction Soil Types , Velocity Tractor with Drivers: 0.3801

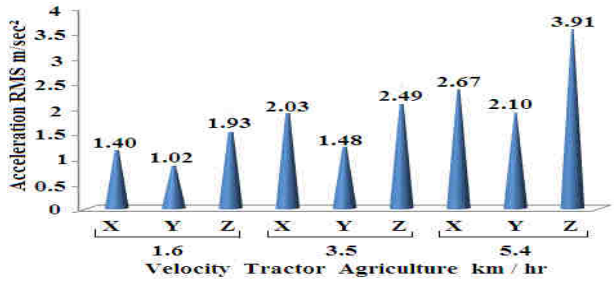

Fig.12 Increasing vibration in seat tractor (Longitudinal X, Lateral Y and Vertical) with increasing Velocity Tractor.

5-2 Heart Rate and Blood Pressure

Table14. Average Heart Rate Blood Pressure (Systolic and Diastolic Pressure) values before and after Tillage. Result show increasing heart rate to the all drivers D1, D2 and D3 after operation tillage. Result found there is no notice change in blood pressure (systolic and diastolic) and found slight increasing (still normal) temperature drivers body. These results agree and the same line with results (Hamid 2012, Fumio et al 2002,Milosevic 1997 and Theorell et al 1985).

Table14. Average Heart Rate, Blood Pressure and Temperature values before and after Tillage.

Drivers	**Heart Rate (beats/min)**		**Blood Pressure (mmHg)***	**Temperature C°**
	Initial	**Final**	**Initial**	**Final**
D1	**75**	**93**	**118/77****	**121/81**
		36.9		**37.2**
D2	**74**	**96**	**117/79**	**120/82**
		37.1		**37.4**
D3	**71**	**89**	**116/78**	**120/80**
		37.0		**37.5**

* **Millimeters of mercury.**
**** The first number 118 is systolic and second number 77 is diastolic.**

III. CONCLUSION

Vibration levels in seat and steering wheel tractor, Daily vibration exposure (8 hours) show highly compare with levels world permeation. Higher vibration transfer in all direction during tillage in dry soil compare with moist soil. Increasing Velocity tractor result to increasing vibration in all main direction (Longitudinal X, Lateral Y and Vertical Z). Driver D3 recorded least vibration compare with drivers D1 and D3. Heart Rate increasing after conducted the experiment for all drivers tractor, Blood Pressure Systolic and Diastolic Not change, Temperature drivers Body was slight increasing but still normal for all drivers tractor.

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